FIG. 1B.

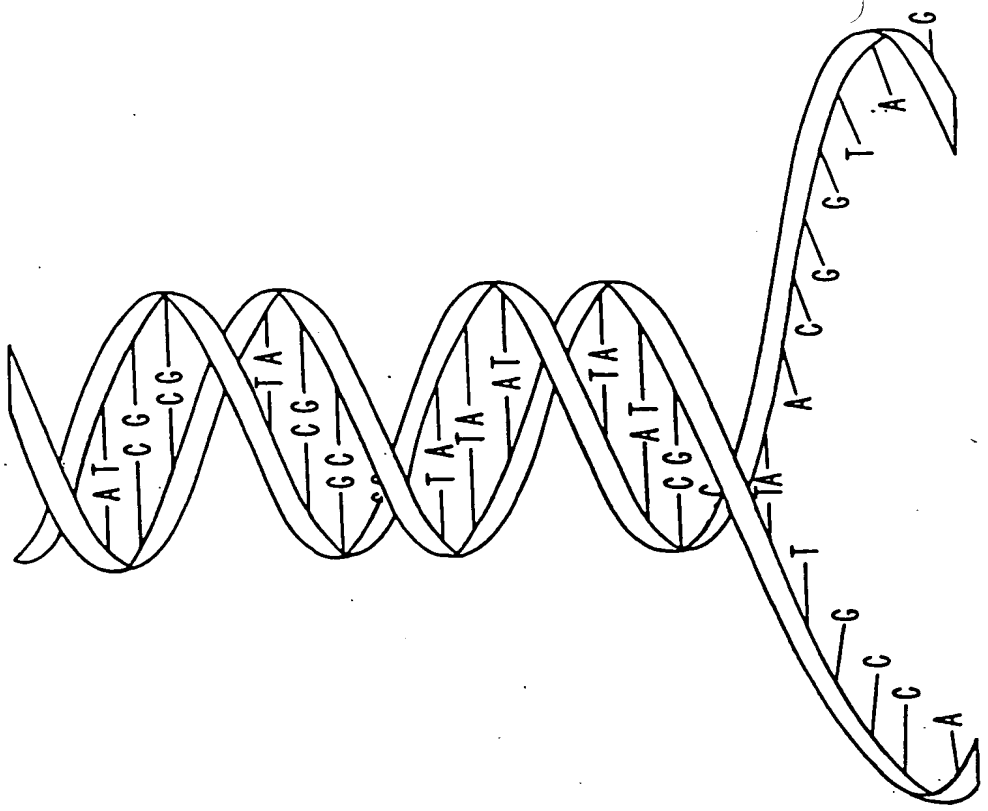
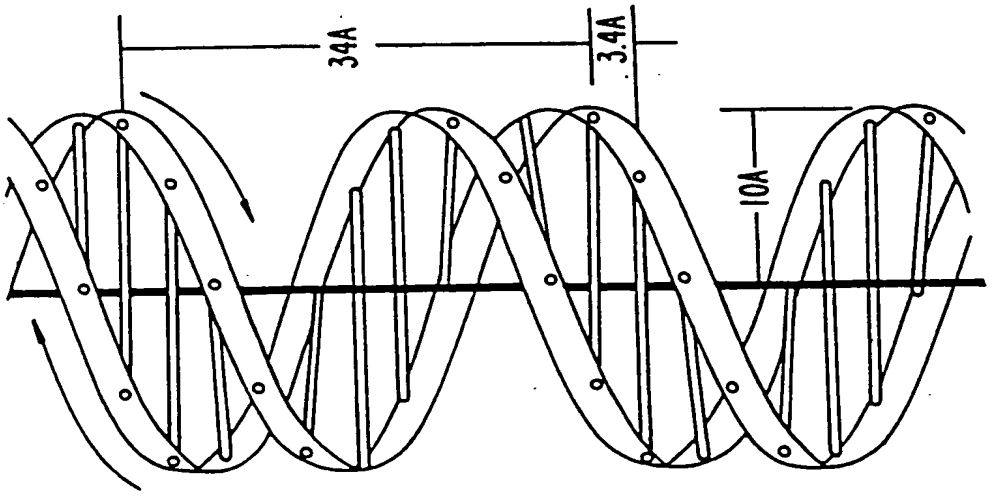


FIG. 1A.



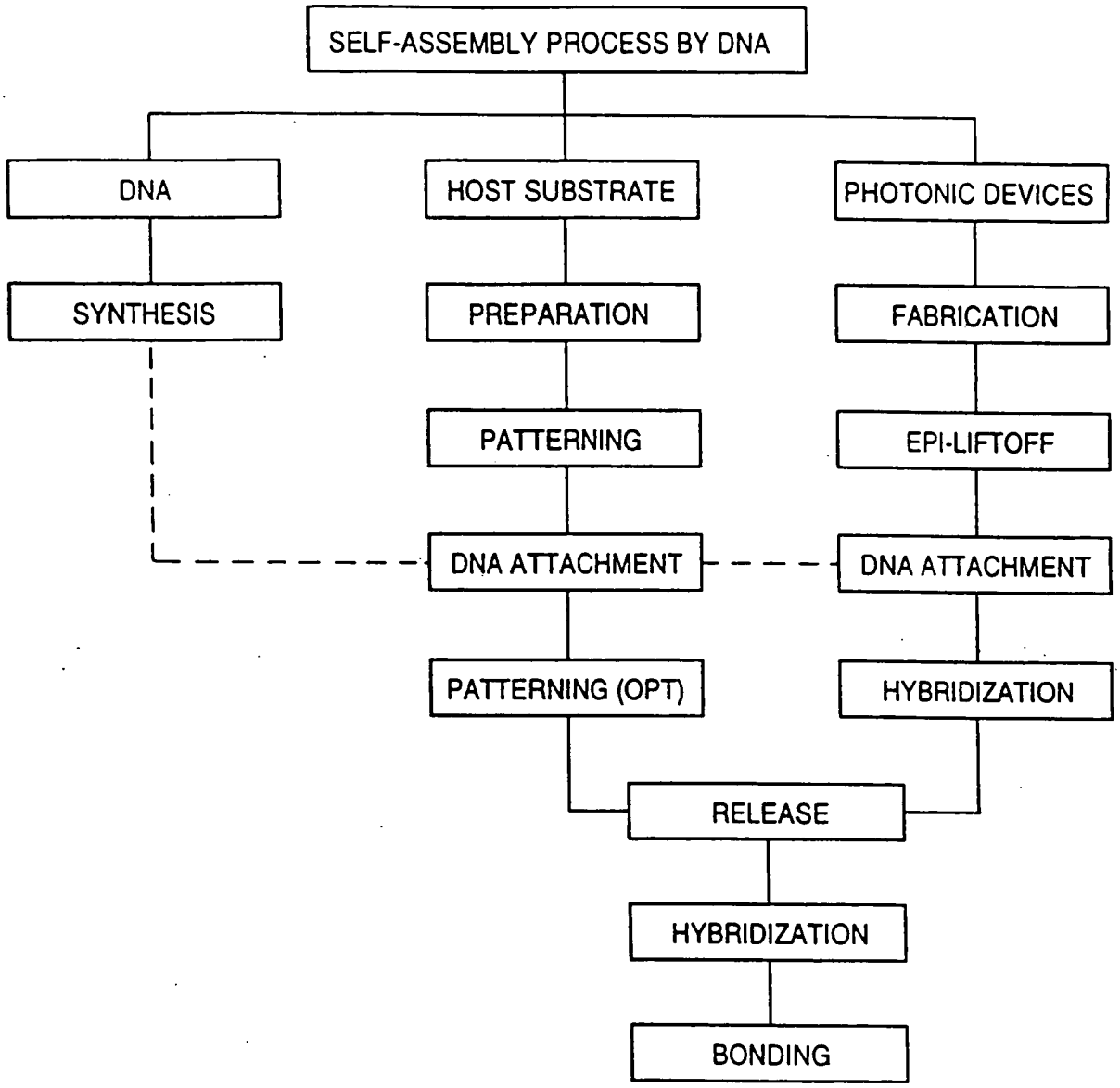

SELF-ASSEMBLY PROCESS BY DNA
DNA
HOST SUBSTRATE
PHOTONIC DEVICES
SYNTHESIS
PREPARATION
FABRICATION
PATTERNING
EPI-LIFTOFF
DNA ATTACHMENT
DNA ATTACHMENT
PATTERNING (OPT)
HYBRIDIZATION
RELEASE
HYBRIDIZATION
BONDING

FIG. 2.

FIG. 3B.

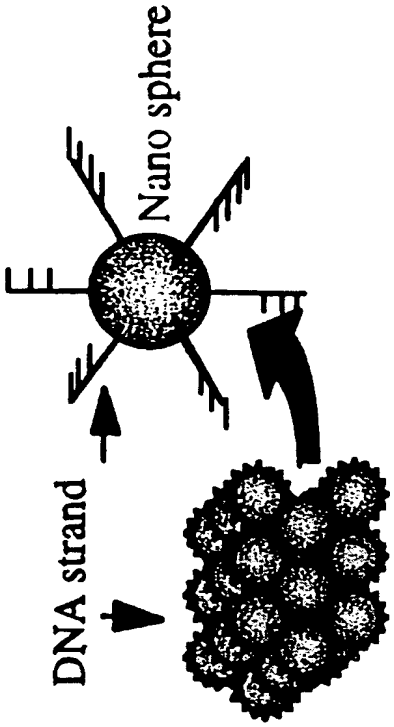
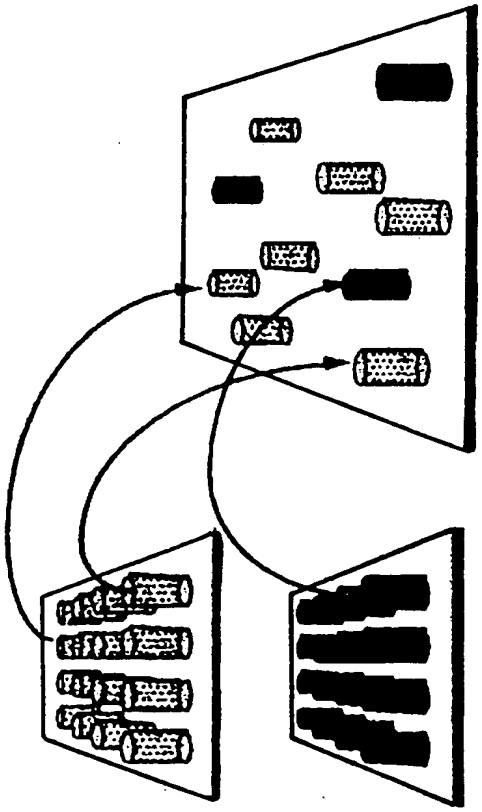


FIG. 3A.



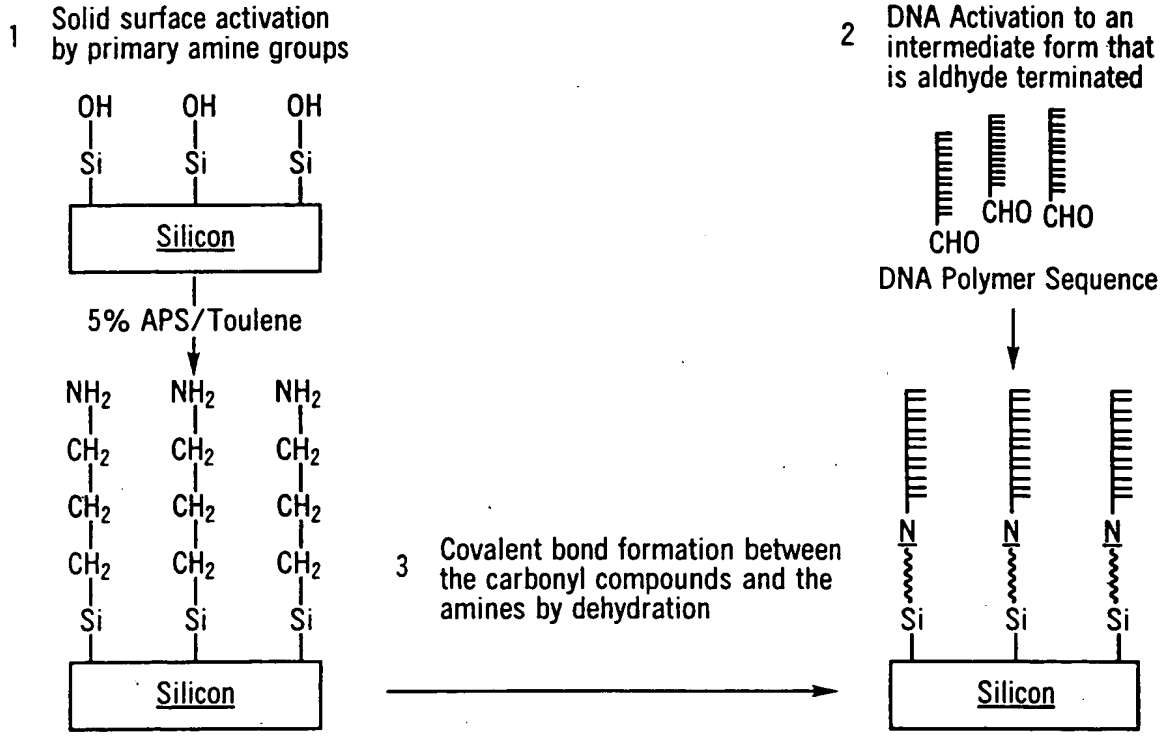
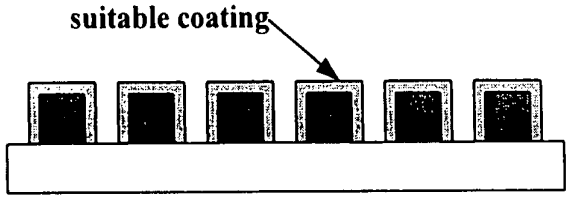

1
Solid surface activation by primary amine groups
OH OH OH
Si Si Si
Silicon
5% APS/Toulene
NH2 NH2 NH2
CH2 CH2 CH2
CH2 CH2 CH2
CH2 CH2 CH2
Si Si Si
Silicon
3
Covalent bond formation between the carbonyl compounds and the amines by dehydration
2
DNA Activation to an intermediate form that is aldhyde terminated
CHO CHO CHO
DNA Polymer Sequence
N N N
Si Si Si
Silicon

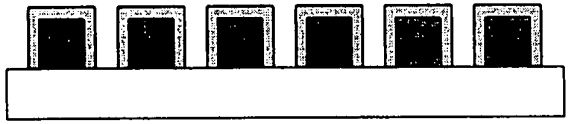
FIG. 4.

1. Standard micro/nano device fab. with sacrificial layer for liftoff

2. Suitable coating of device surface for quasi-Brownian motion capability



3. Support with polyimide or black wax

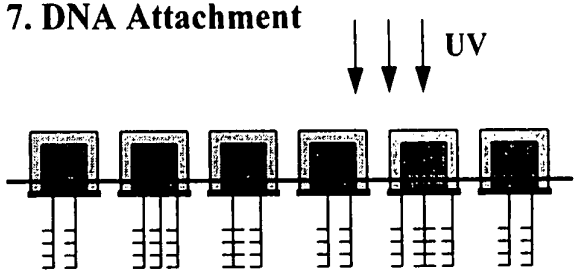


4. Epi-liftoff

5. Polyimide recess

6. Metalization

7. DNA Attachment



8. Release

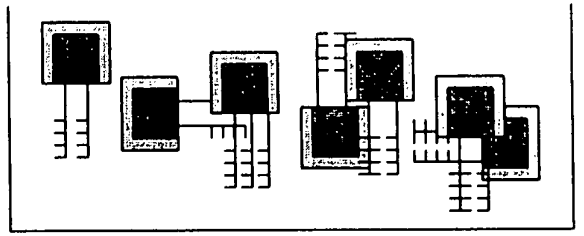


Fig. 5

FIG. 7

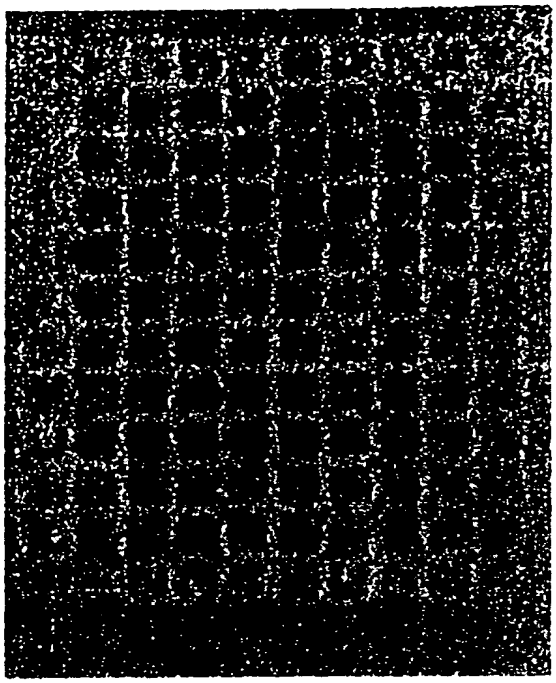


FIG. 6

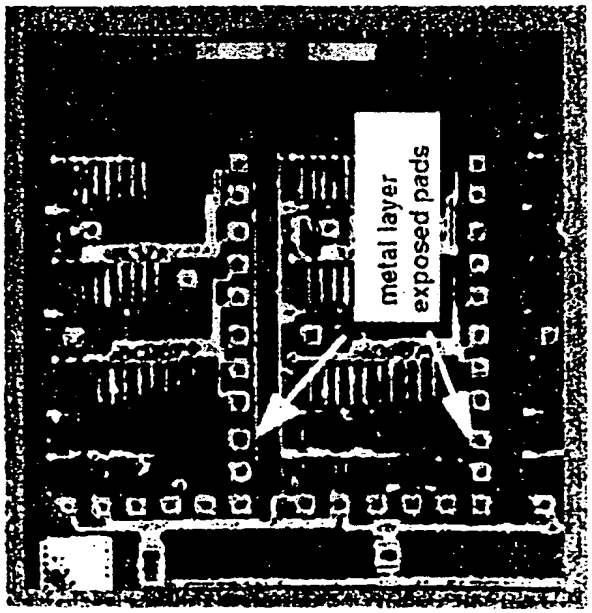


FIG. 8B

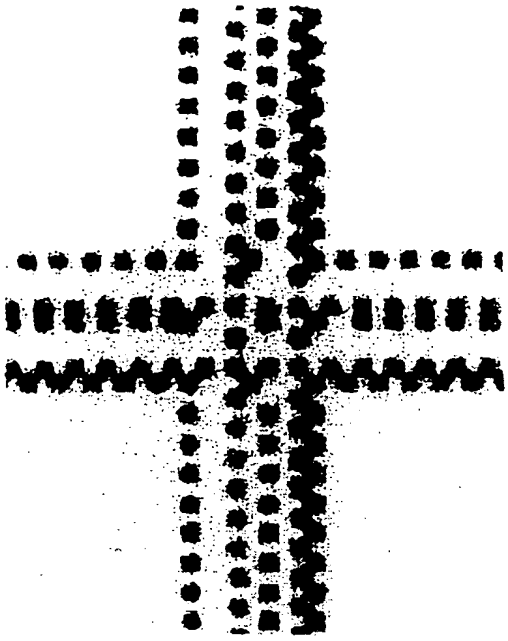


FIG. 8A

FIG. 9

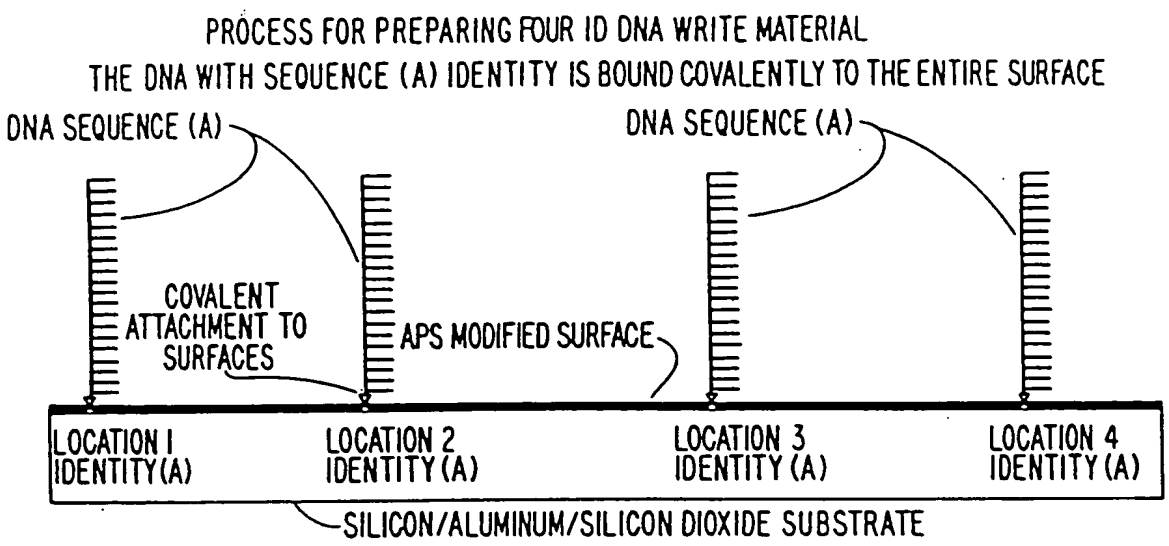

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL
THE DNA WITH SEQUENCE (A) IDENTITY IS BOUND COVALENTLY TO THE ENTIRE SURFACE
DNA SEQUENCE (A)
DNA SEQUENCE (A)
COVALENT ATTACHMENT TO SURFACES
APS MODIFIED SURFACE
LOCATION 1 IDENTITY (A)
LOCATION 2 IDENTITY (A)
LOCATION 3 IDENTITY (A)
LOCATION 4 IDENTITY (A)
SILICON/ALUMINUM/SILICON DIOXIDE SUBSTRATE

FIG. 10

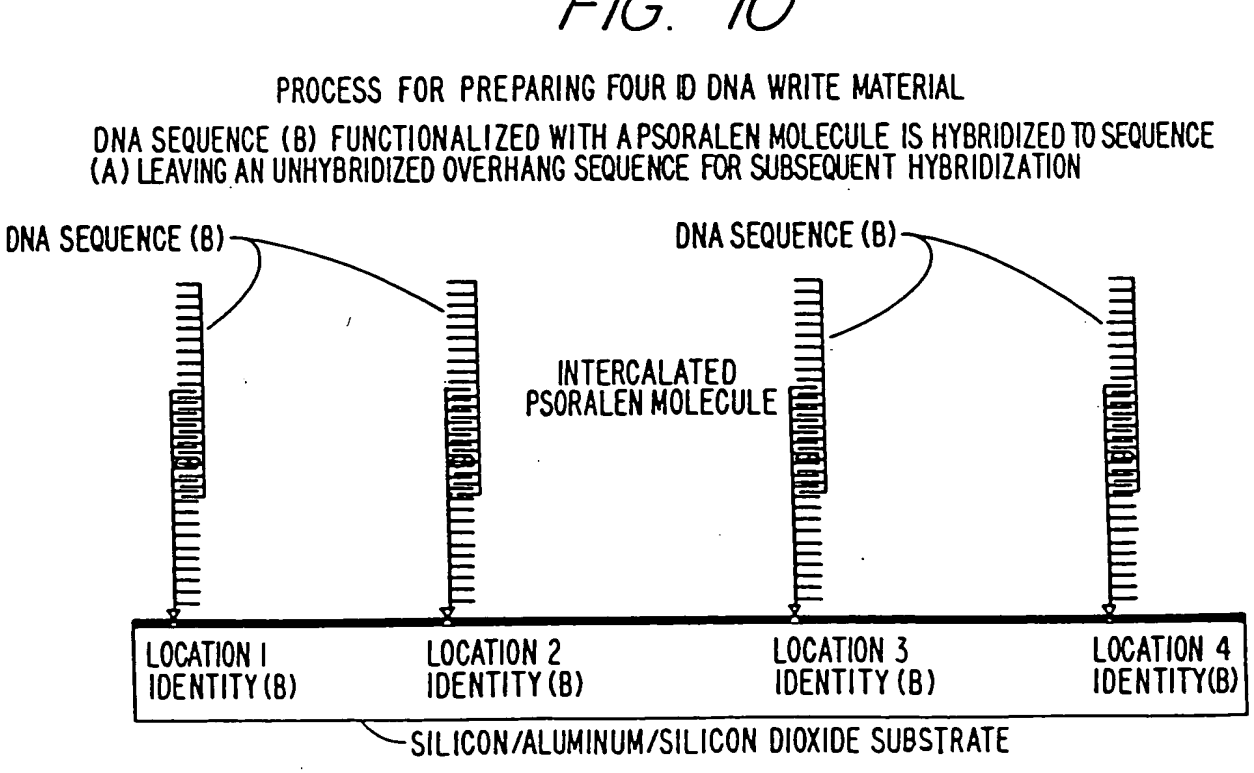

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL
DNA SEQUENCE (B) FUNCTIONALIZED WITH A PSORALEN MOLECULE IS HYBRIDIZED TO SEQUENCE (A) LEAVING AN UNHYBRIDIZED OVERHANG SEQUENCE FOR SUBSEQUENT HYBRIDIZATION
DNA SEQUENCE (B)
DNA SEQUENCE (B)
INTERCALATED PSORALEN MOLECULE
LOCATION 1 IDENTITY (B)
LOCATION 2 IDENTITY (B)
LOCATION 3 IDENTITY (B)
LOCATION 4 IDENTITY (B)
SILICON/ALUMINUM/SILICON DIOXIDE SUBSTRATE

FIG. 11

LOCATION #1 IS MASKED FROM UV EXPOSURE WHILE LOCATIONS 2,3 & 4 ARE EXPOSED ALLOWING THE PSORALEN MOLECULES TO COVALENTLY CROSS-LINK THE (A) AND (B) DNA SEQUENCE.

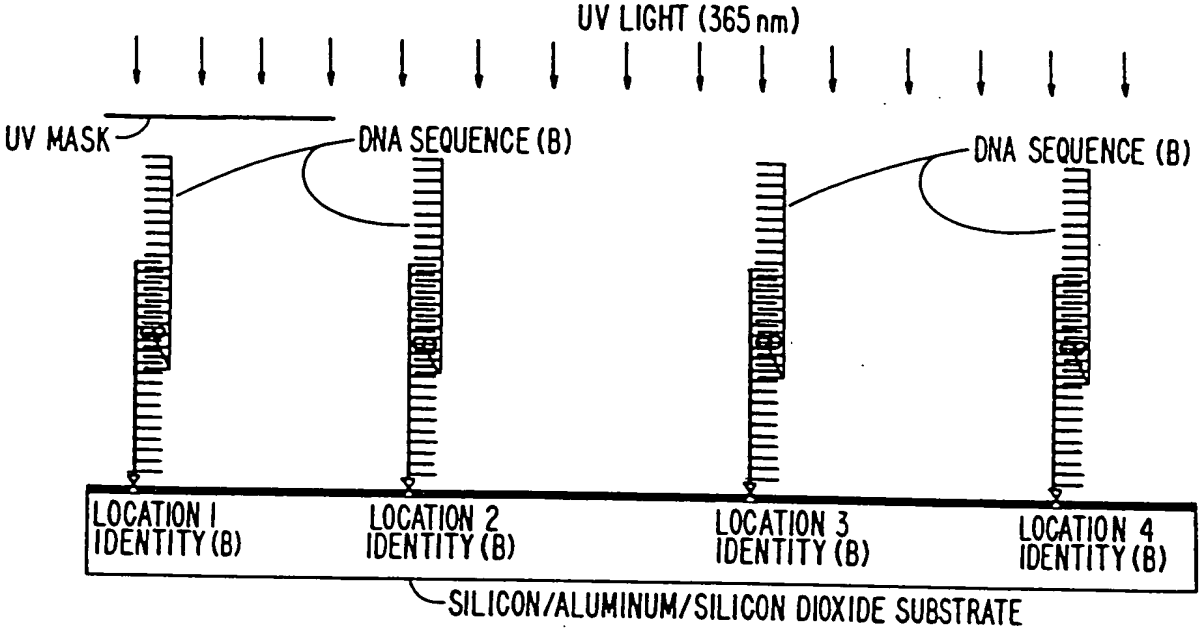


FIG. 12

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

DEHYBRIDIZATION IS CARRIED OUT TO REMOVE THE NON-CROSSLINKED SEQUENCE (B) FROM THE 1st LOCATION, WHICH NOW HAS A PERMANENT (A) SEQUENCE IDENTITY. DNA SEQUENCE (B) IS NOW COVALENTLY COUPLED TO LOCATIONS 2, 3 AND 4

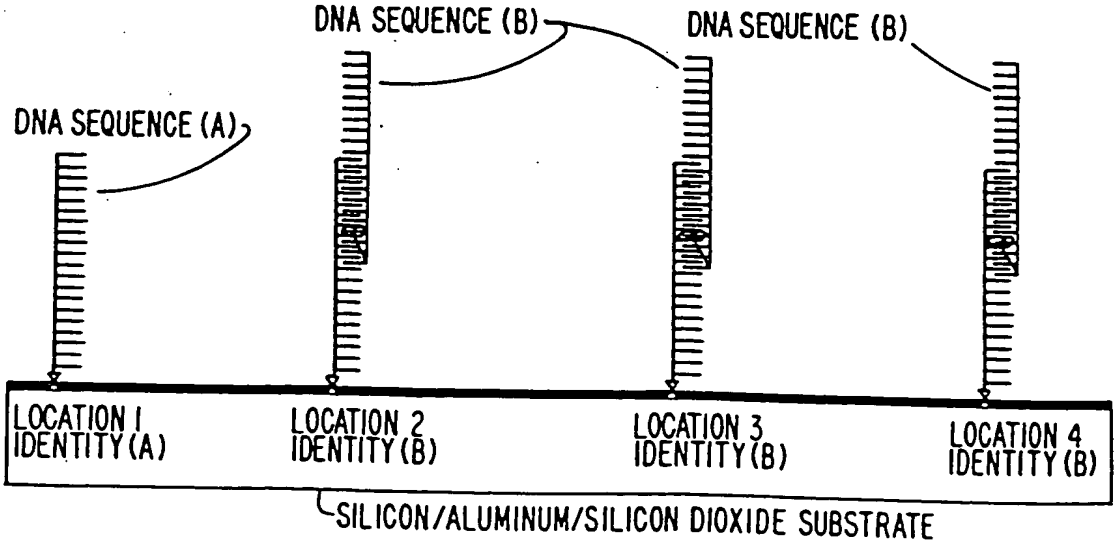


FIG. 13.

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

A PSORALEN FUCTIONALIZED DNA SEQUENCE (C) IS NOW HYBRIDIZED TO SEQUENCE (B), AND THE PROCESS IS REPEATED.

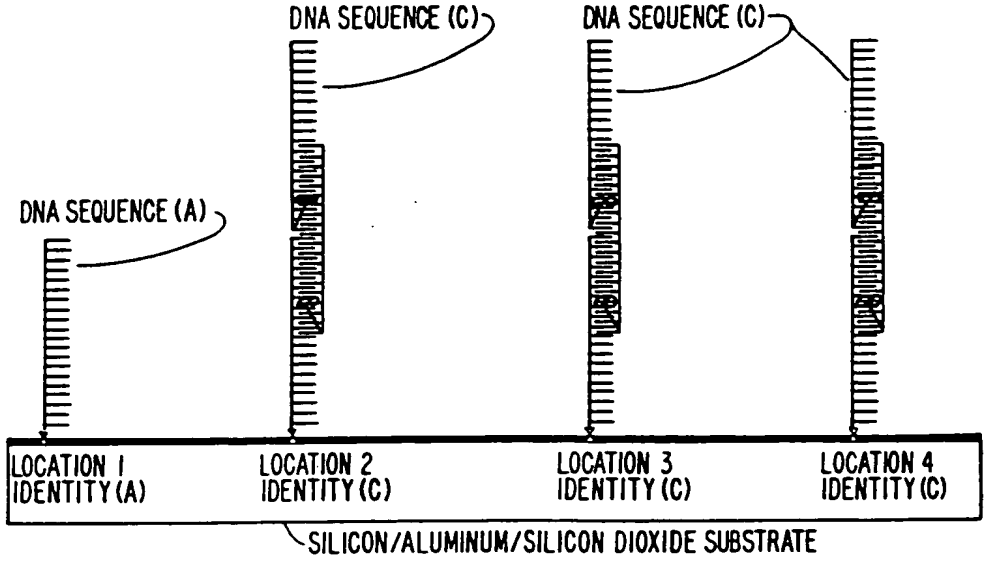


FIG. 14.

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

LOCATIONS 1 AND 2 ARE NOW MASKED WHILE LOCATIONS 3 AND 4 ARE EXPOSED AFFECTING THE COVALENT CROSS-LINKING OF SEQUENCES (B) AND (C).

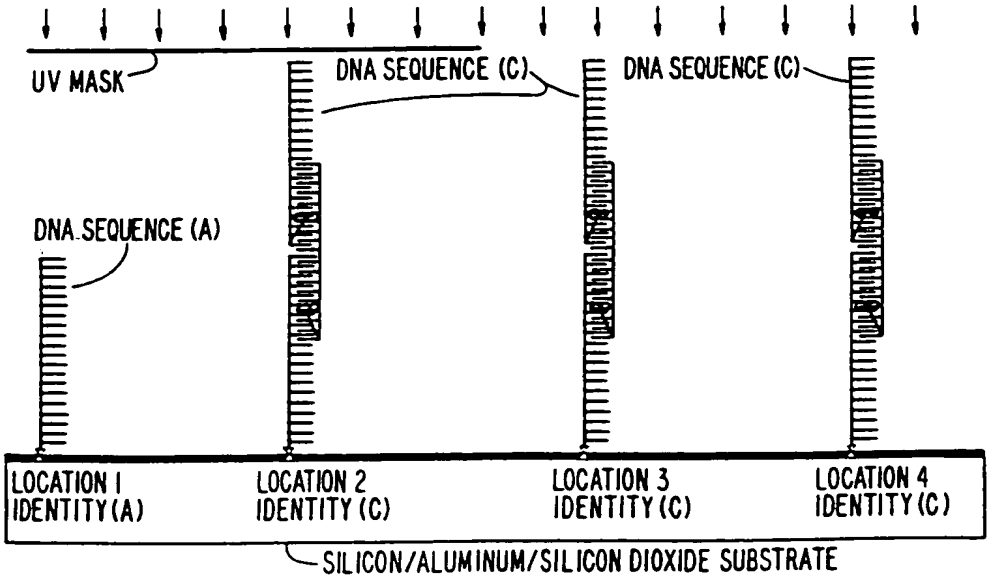


FIG. 15

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

DEHYBRIDIZATION IS CARRIED OUT TO REMOVE SEQUENCE (C) FROM LOCATION 2. A PERMANENT (B) DNA SEQUENCE IDENTITY IS NOW PRESENT AT LOCATION 2

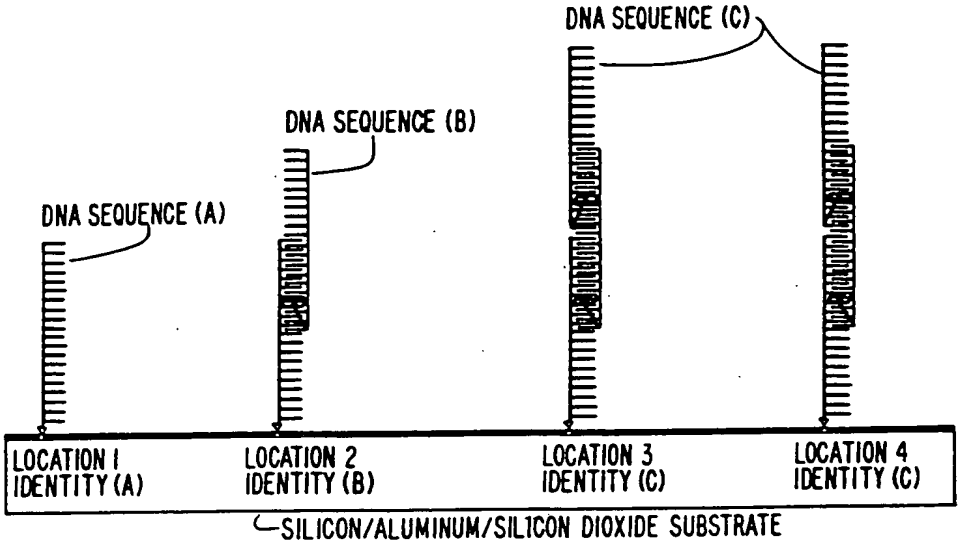


FIG. 16

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

A PSORALEN FUCTIONALIZED DNA SEQUENCE (D) IS NOW HYBRIDIZED TO SEQUENCE (C), AND THE PROCESS IS REPEATED.

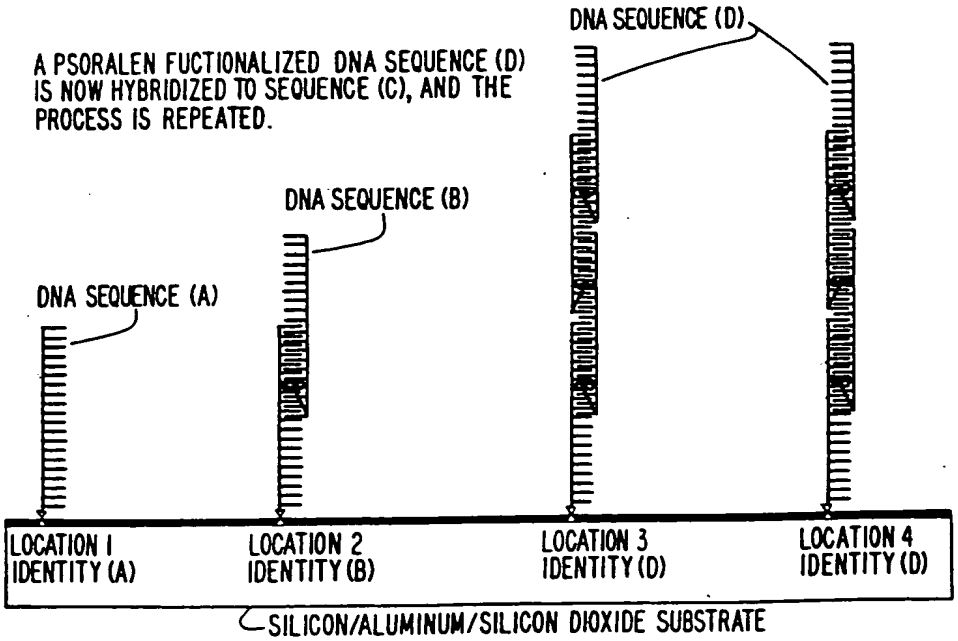


FIG. 17

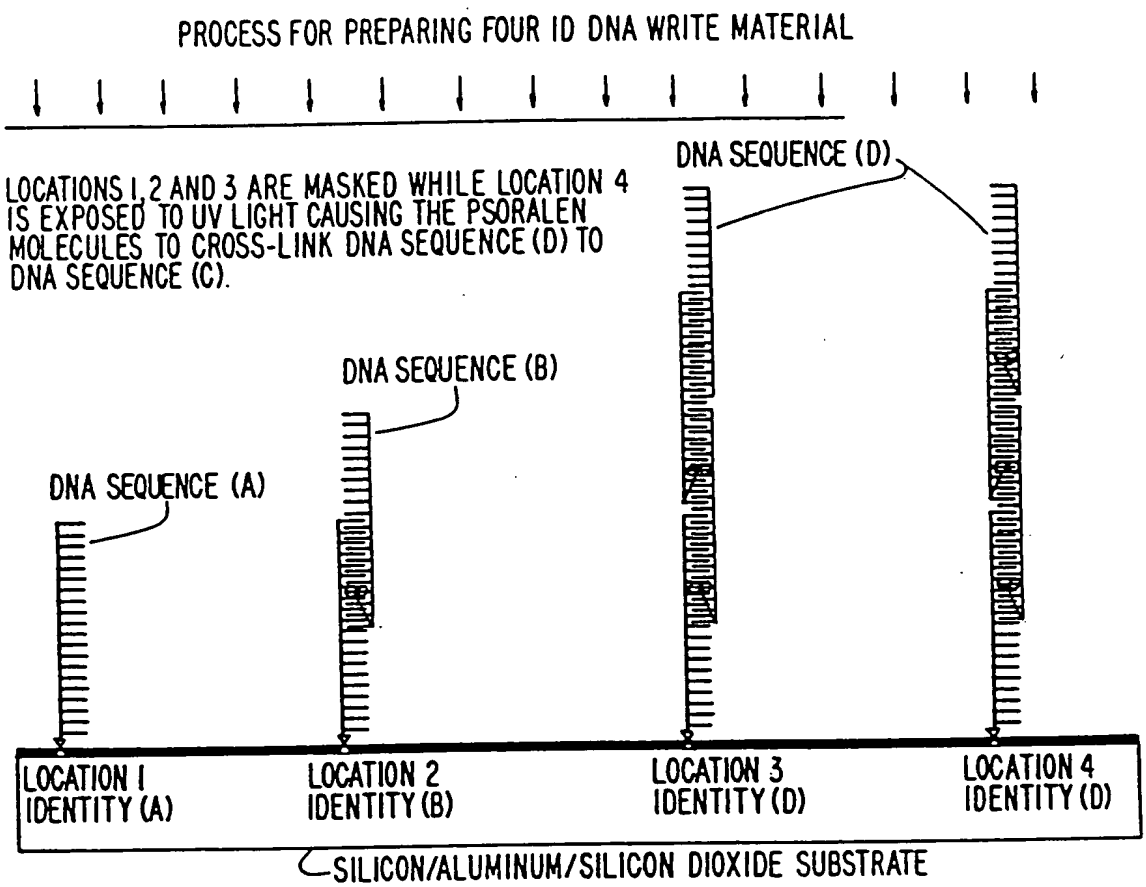

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL
LOCATIONS 1, 2 AND 3 ARE MASKED WHILE LOCATION 4 IS EXPOSED TO UV LIGHT CAUSING THE PSORALEN MOLECULES TO CROSS-LINK DNA SEQUENCE (D) TO DNA SEQUENCE (C).
DNA SEQUENCE (D)
DNA SEQUENCE (B)
DNA SEQUENCE (A)
LOCATION 1 IDENTITY (A)
LOCATION 2 IDENTITY (B)
LOCATION 3 IDENTITY (D)
LOCATION 4 IDENTITY (D)
SILICON/ALUMINUM/SILICON DIOXIDE SUBSTRATE

FIG. 18

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

DEHYBRIDIZATION IS CARRIED OUT TO REMOVE DNA SEQUENCE (D) FROM LOCATION 3. A PERMANENT (C) IDENTITY IS PRESENT AT LOCATION 3 AND A PERMANENT (D) IDENTITY IS PRESENT AT LOCATION 4. THIS COMPLETES THE PROCESS FOR PREPARING A FOUR ID DNA WRITE MATERIAL.

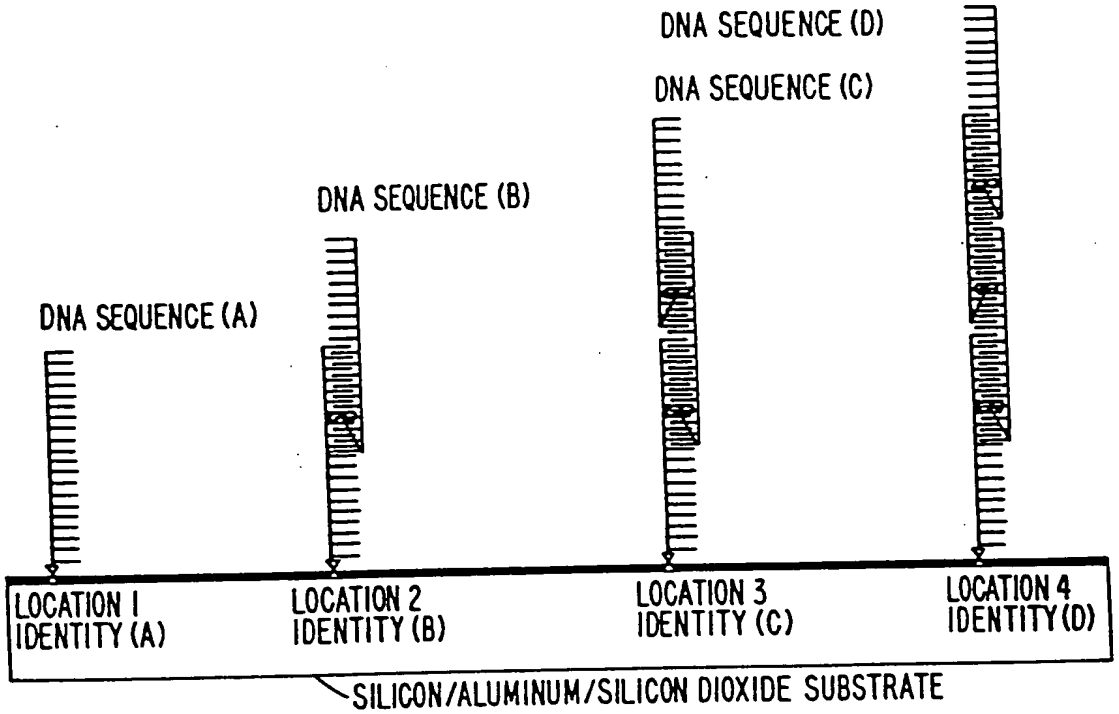


FIG. 19

PROCESS FOR PREPARING FOUR ID DNA WRITE MATERIAL

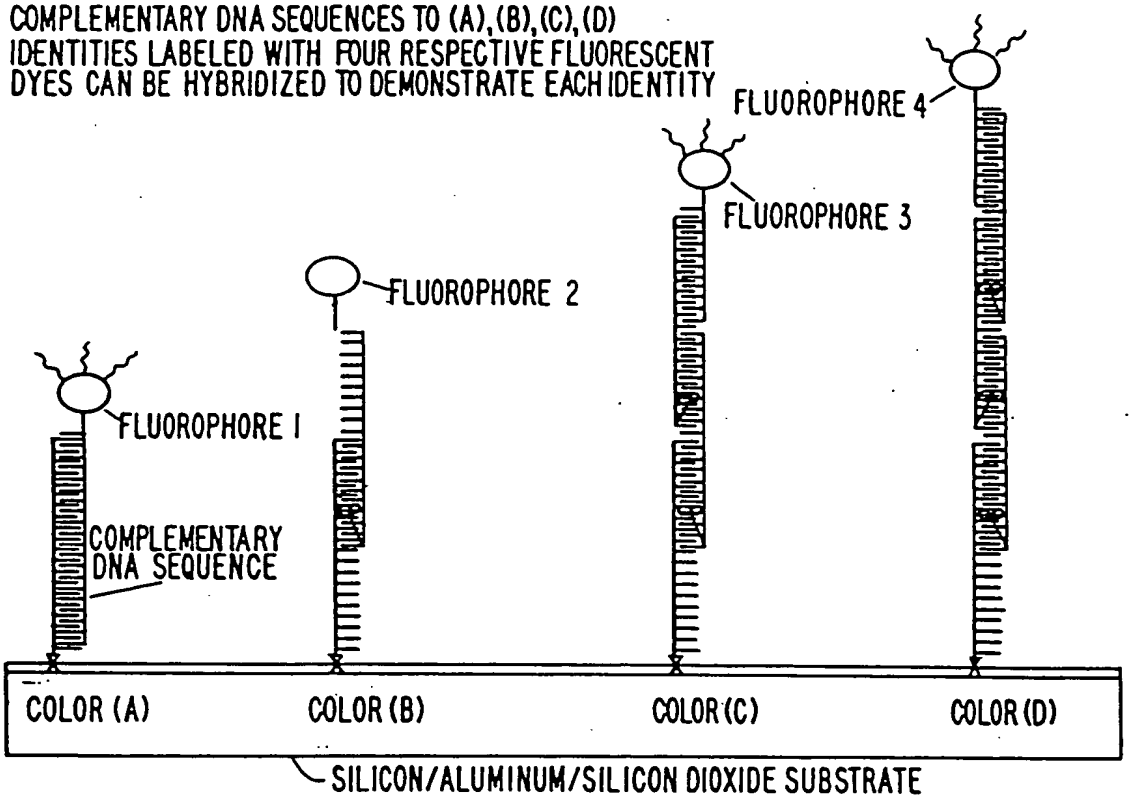


FIG. 20

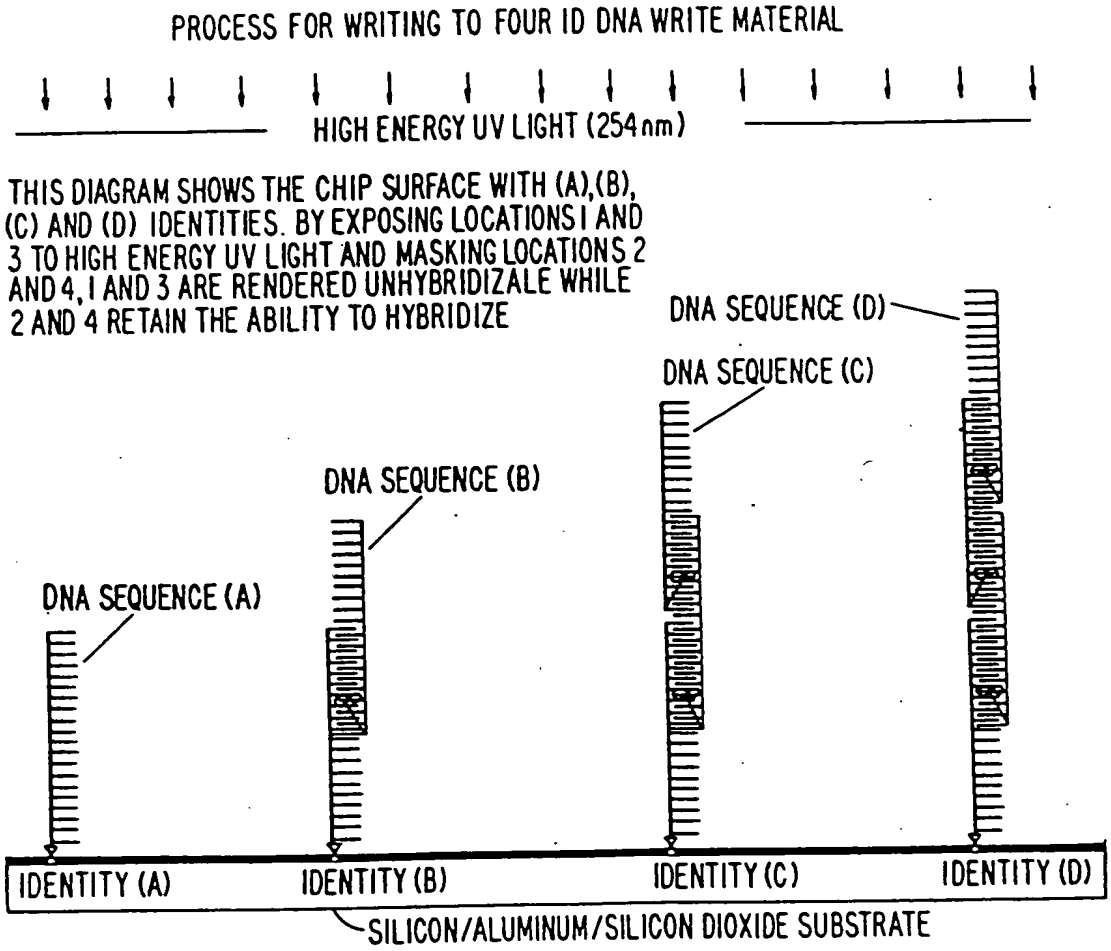

PROCESS FOR WRITING TO FOUR ID DNA WRITE MATERIAL
HIGH ENERGY UV LIGHT (254 nm)
THIS DIAGRAM SHOWS THE CHIP SURFACE WITH (A),(B), (C) AND (D) IDENTITIES. BY EXPOSING LOCATIONS 1 AND 3 TO HIGH ENERGY UV LIGHT AND MASKING LOCATIONS 2 AND 4, 1 AND 3 ARE RENDERED UNHYBRIDIZALE WHILE 2 AND 4 RETAIN THE ABILITY TO HYBRIDIZE
DNA SEQUENCE (D)
DNA SEQUENCE (C)
DNA SEQUENCE (B)
DNA SEQUENCE (A)
IDENTITY (A)
IDENTITY (B)
IDENTITY (C)
IDENTITY (D)
SILICON/ALUMINUM/SILICON DIOXIDE SUBSTRATE

FIG. 21

PROCESS FOR WRITING TO FOUR ID DNA WRITE MATERIAL

SELECTIVE UV EXPOSURE LEAVES LOCATIONS 1 AND 3 UNHYBRIDIZABLE AND LOCATIONS 2 AND 4 RETAIN THE ABILITY TO HYBRIDIZE

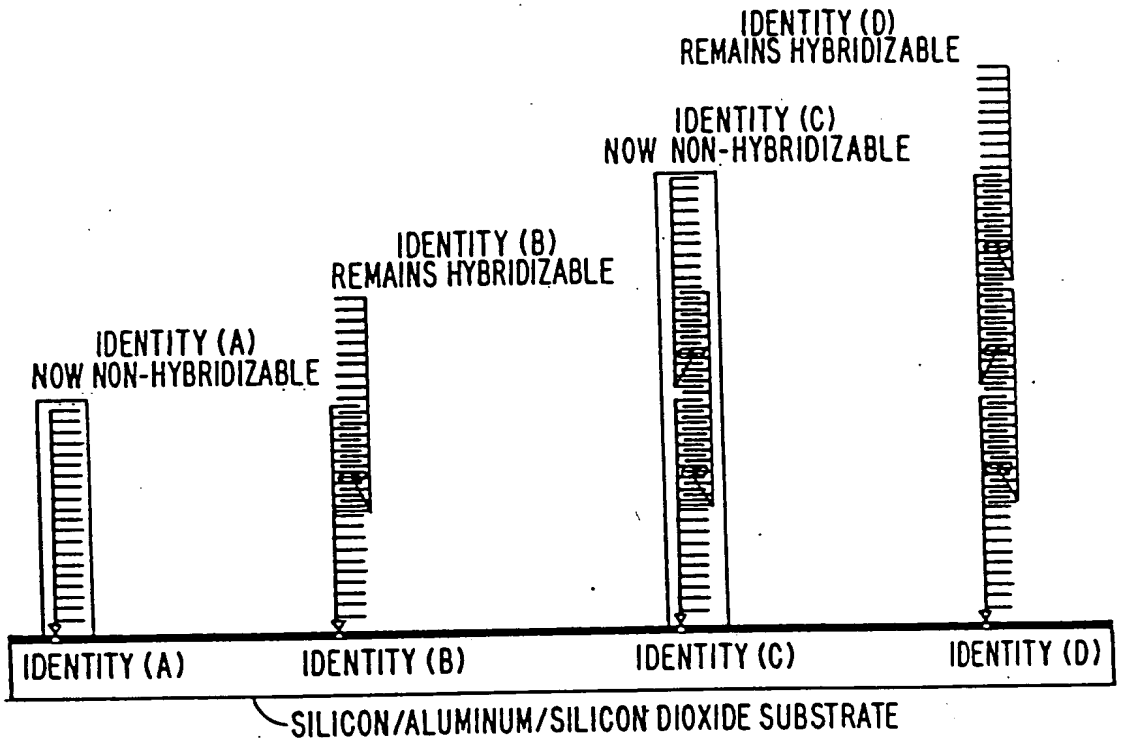


FIG. 22.

PROCESS FOR WRITING TO FOUR ID DNA WRITE MATERIAL

ALL 4 DNA COMPLEMENTS LABELED WITH THEIR RESPECTIVE FLUORPHORES ARE APPLIED TO THE SURFACE, ONLY LOCATIONS (B) AND (D) HYBRIDIZE THEIR RESPECTIVE FLUORESCENT COMPLEMENTS

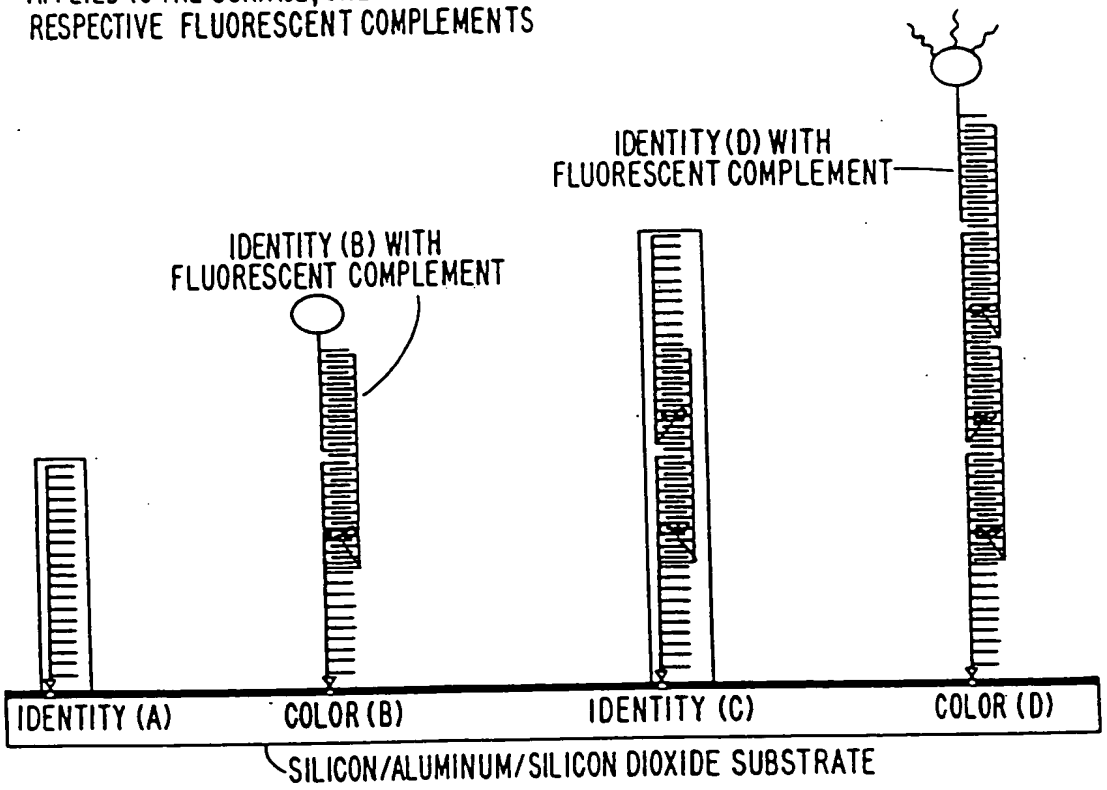


FIG. 23B

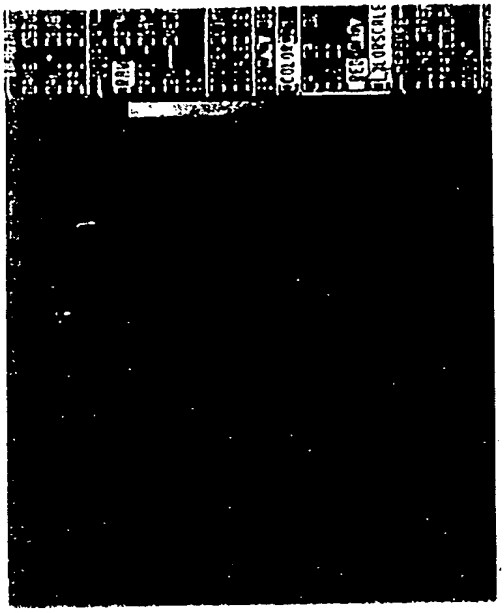


FIG. 23A

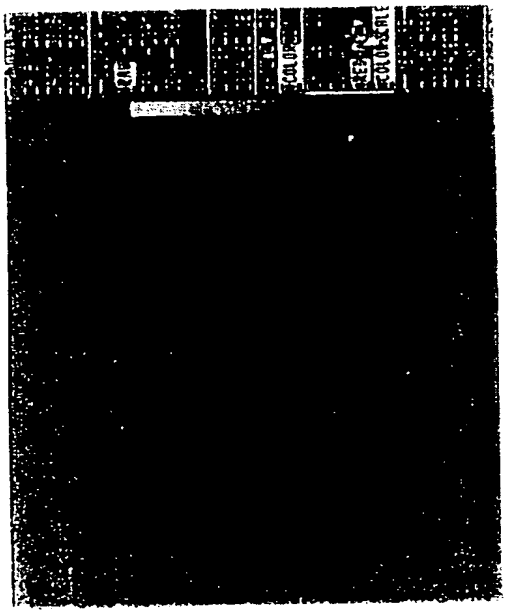


FIG. 24B

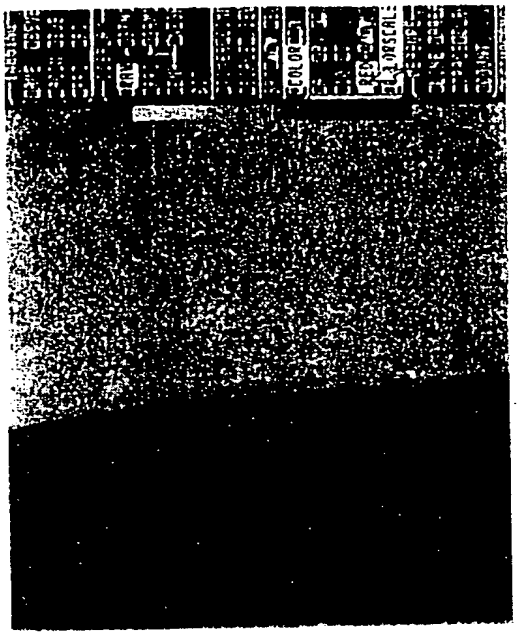


FIG. 24A

FIG. 25B

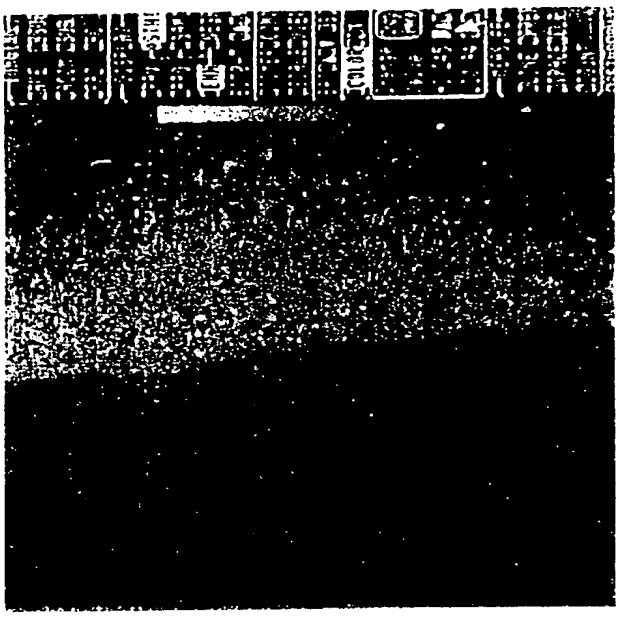


FIG. 25A

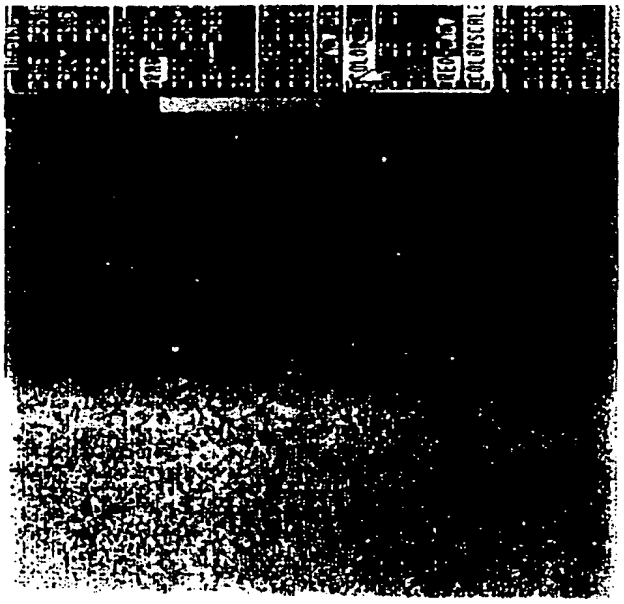


FIG. 26A

FIG. 26B

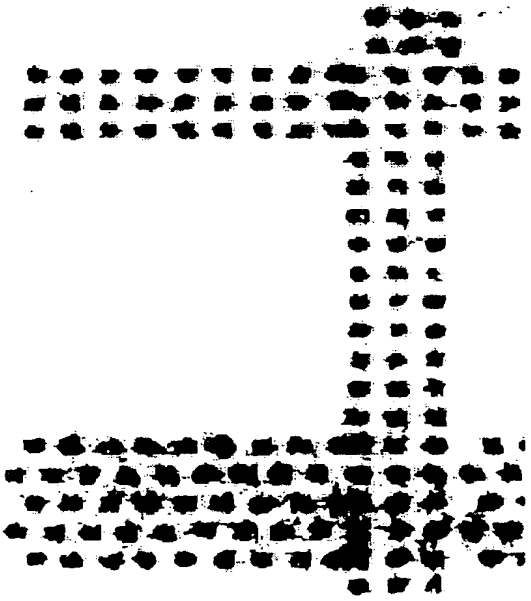
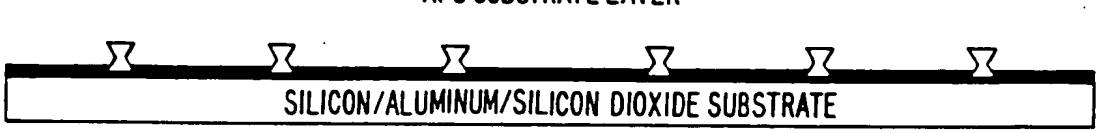
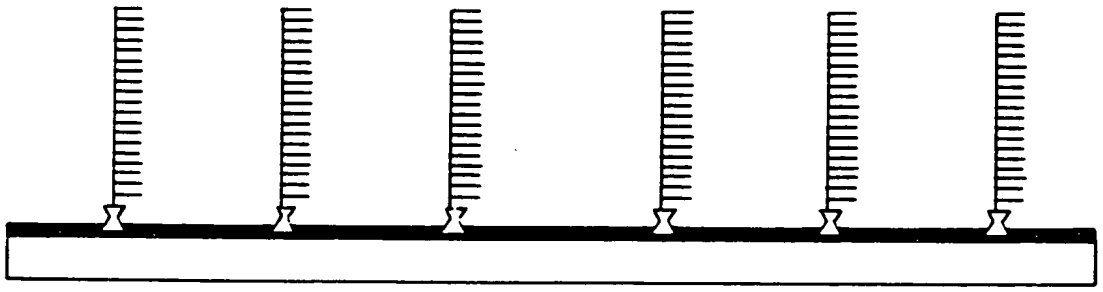


FIG. 27A



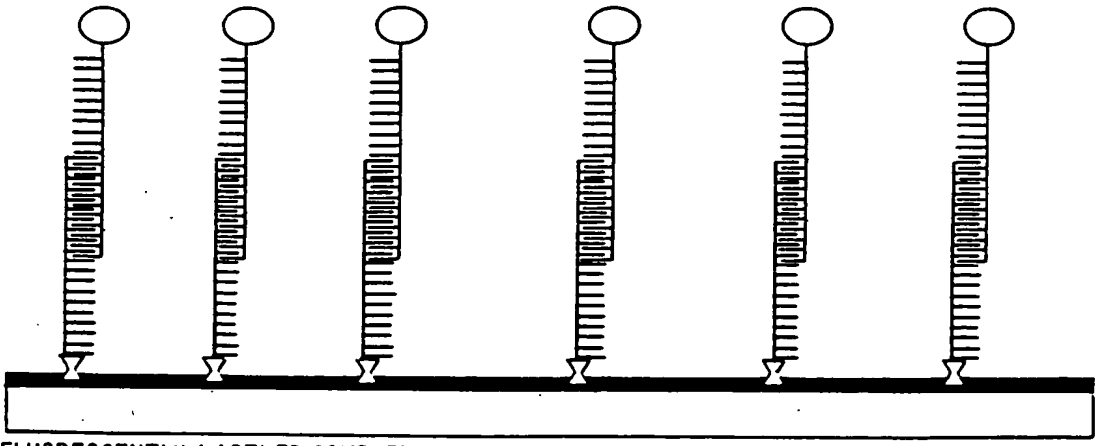
CHIP SURFACE IS FUNCTIONALIZED ONLY WITH APS

FIG. 27B



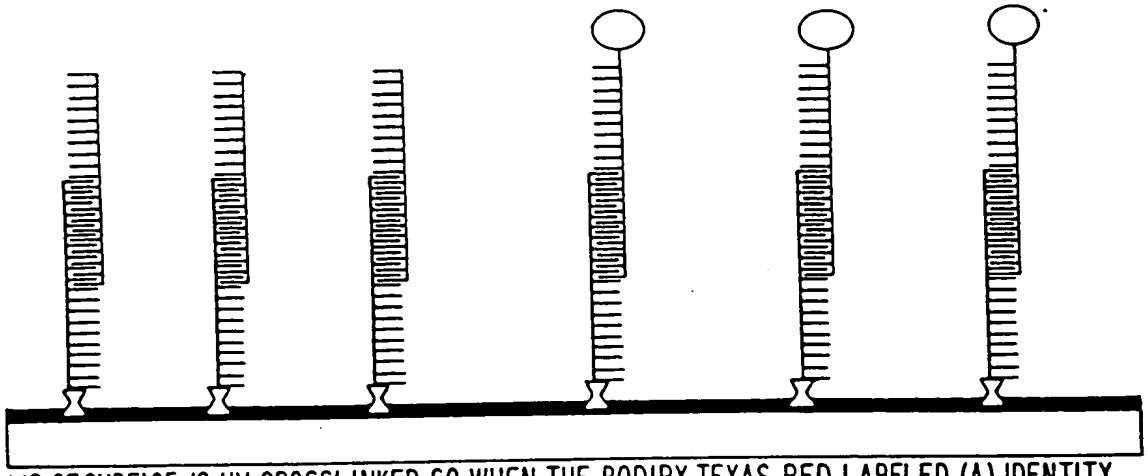
ORIGINAL CAPTURE DNA SEQUENCE A, WHICH IS NOT FLUORESCENTLY LABELED, IS COVALENTLY ATTACHED TO THE APS LAYER ON THE CHIP SURFACE

FIG. 27C



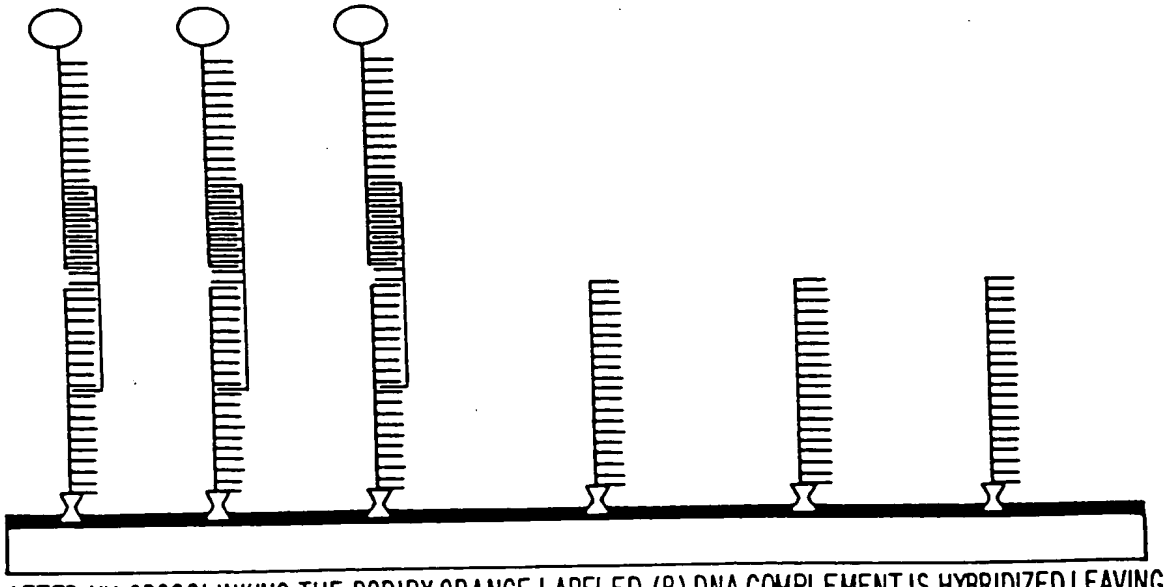
FLUORESCENTLY LABELED COMPLEMENTARY DNA SEQUENCE TO THE (A) IDENTITY ON THE SURFACE IS HYBRIDIZED TO THE ENTIRE CHIP LEAVING THE ENTIRE SURFACE BRIGHT

FIG. 28A



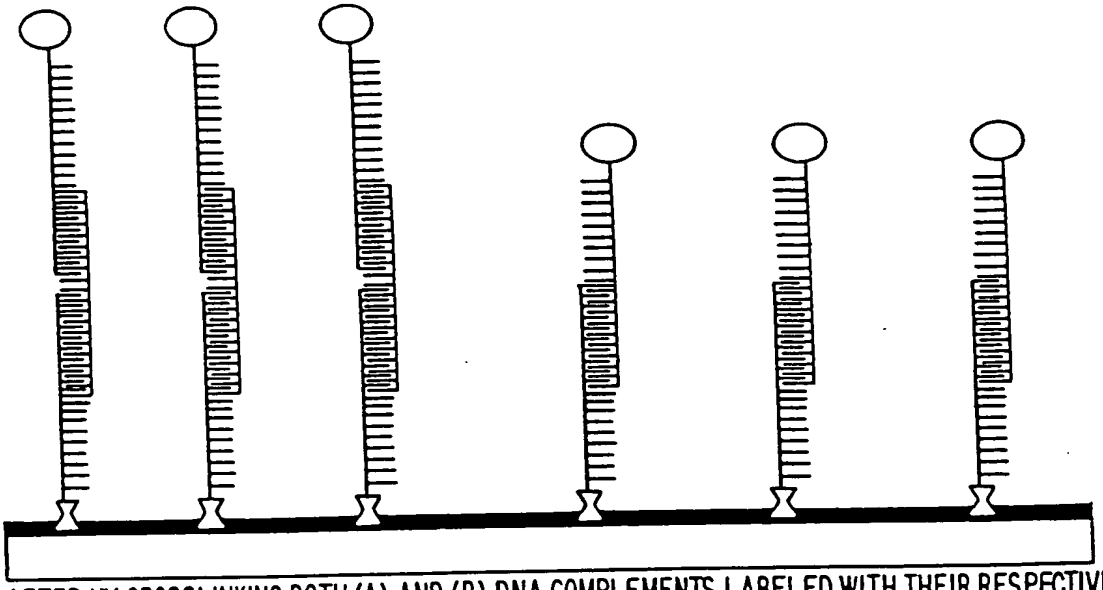
1/2 OF SURFACE IS UV CROSSLINKED SO WHEN THE BODIPY TEXAS RED LABELED (A) IDENTITY COMPLEMENT IS HYBRIDIZED ACROSS THE ENTIRE CHIP ONLY THE NON-CROSSLINKED RIGHT SIDE OF THE CHIP ATTAINS COLOR

FIG. 28B



AFTER UV CROSSLINKING THE BODIPY ORANGE LABELED (B) DNA COMPLEMENT IS HYBRIDIZED LEAVING ONLY THE (B) IDENTITY LEFT SIDE OF THE CHIP BRIGHT

FIG. 28C



AFTER UV CROSSLINKING BOTH (A) AND (B) DNA COMPLEMENTS LABELED WITH THEIR RESPECTIVE FLUOROPHORES ARE HYBRIDIZED TO THE SURFACE, THE LEFT SIDE ATTAINING THE BODIPY ORANGE AND THE RIGHT ATTAINING THE BODIPY TEXAS RED COLOR

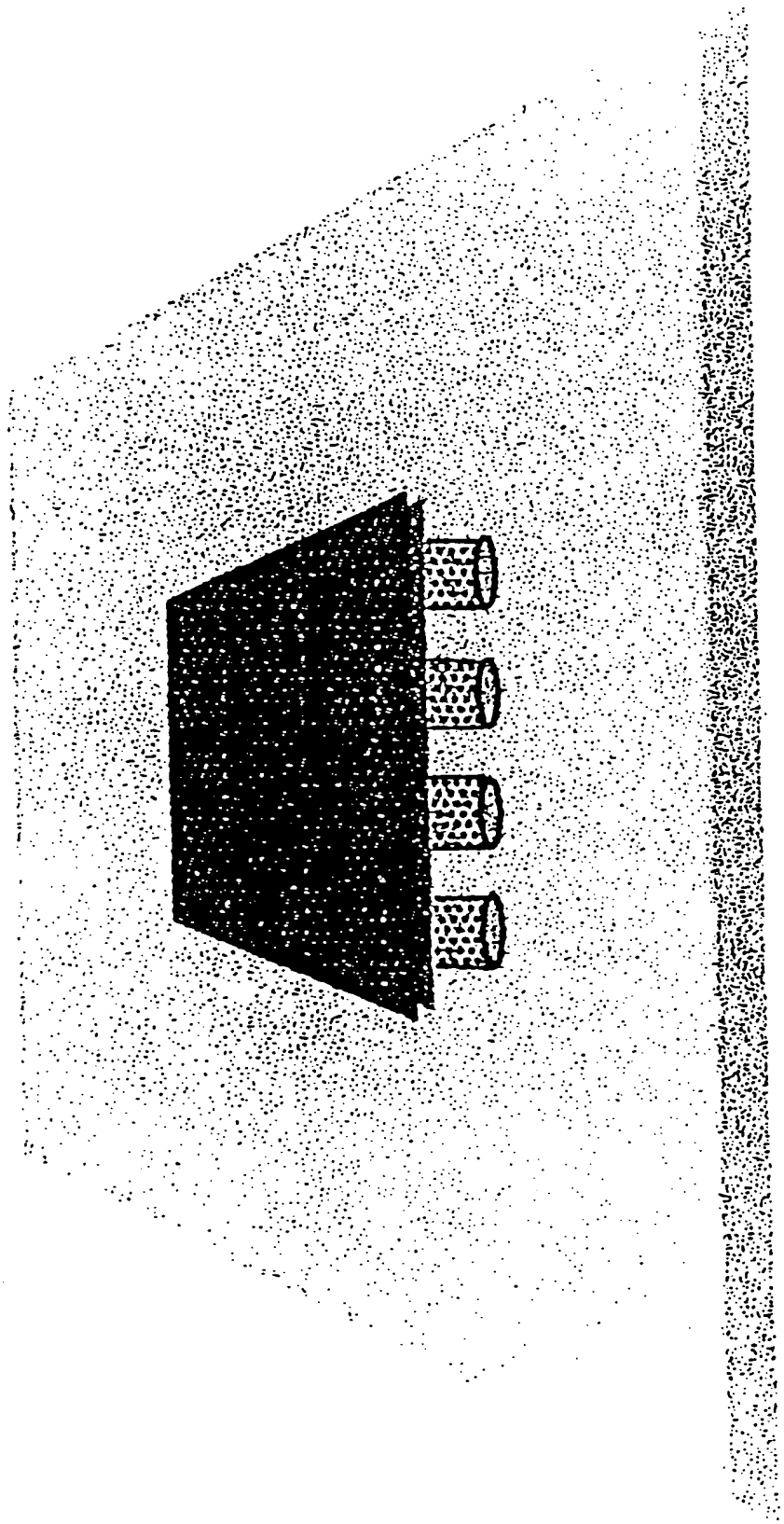


FIG. 29

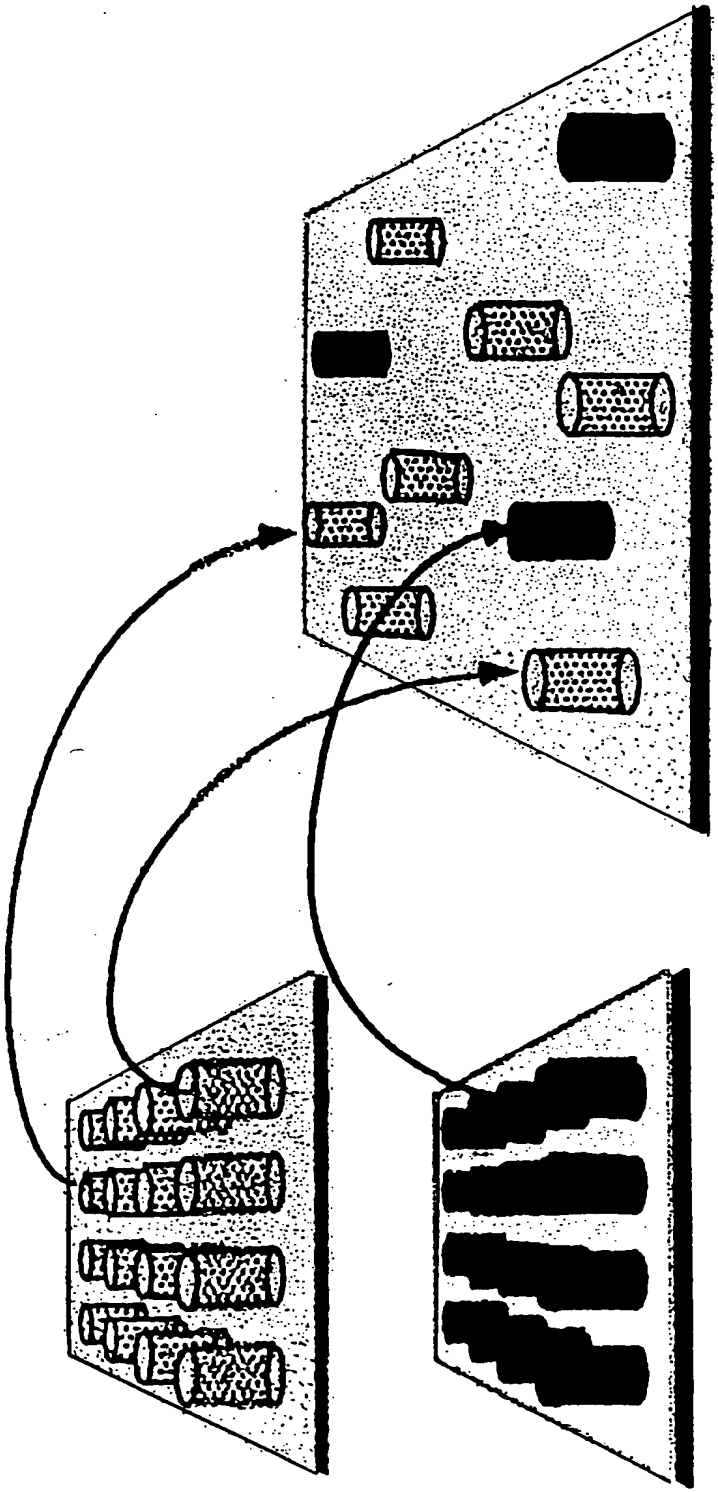
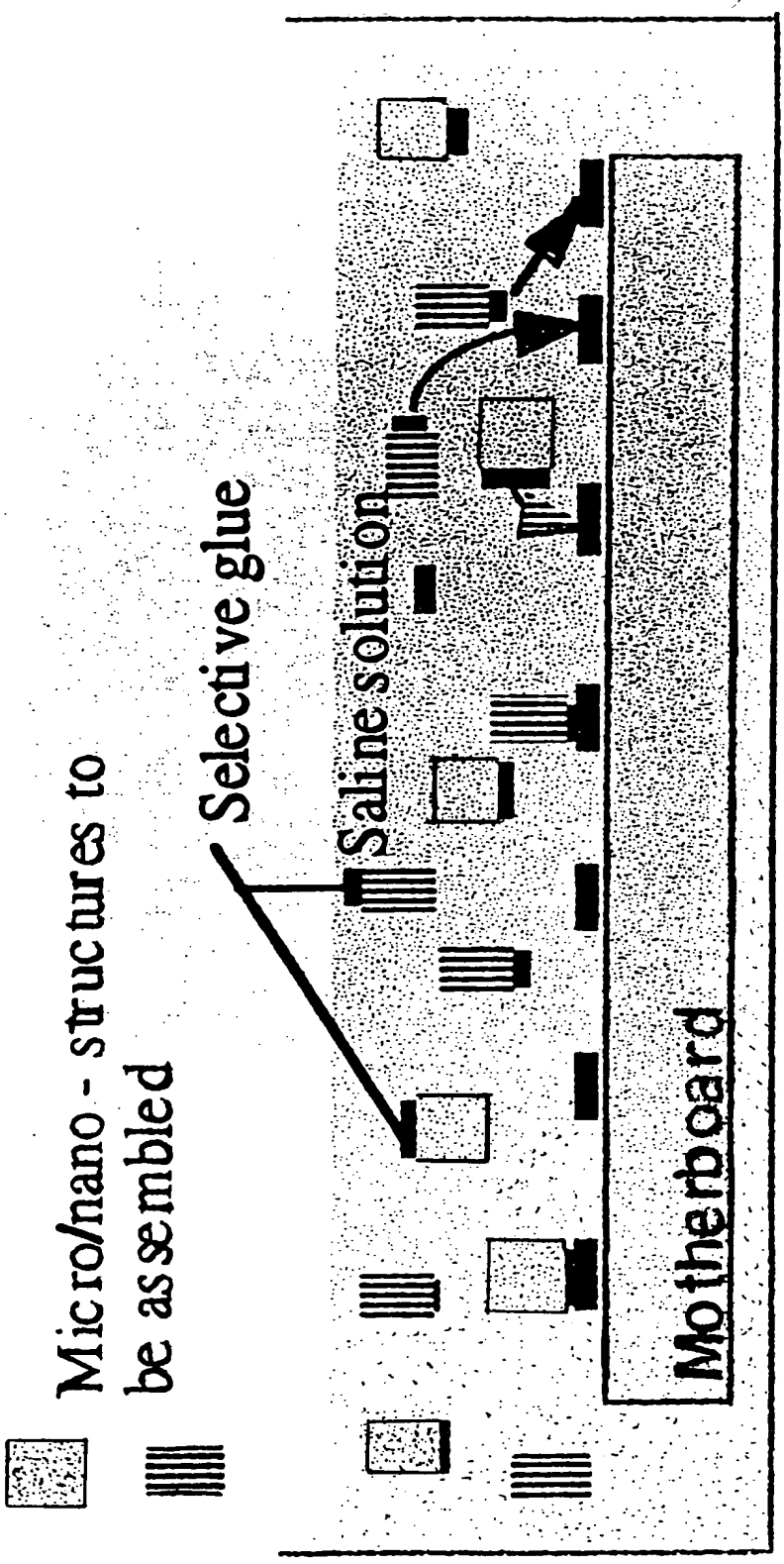


FIG. 30

FIG. 31


Micro/nano - structures to be assembled
Selective glue
Saline solution
Motherboard

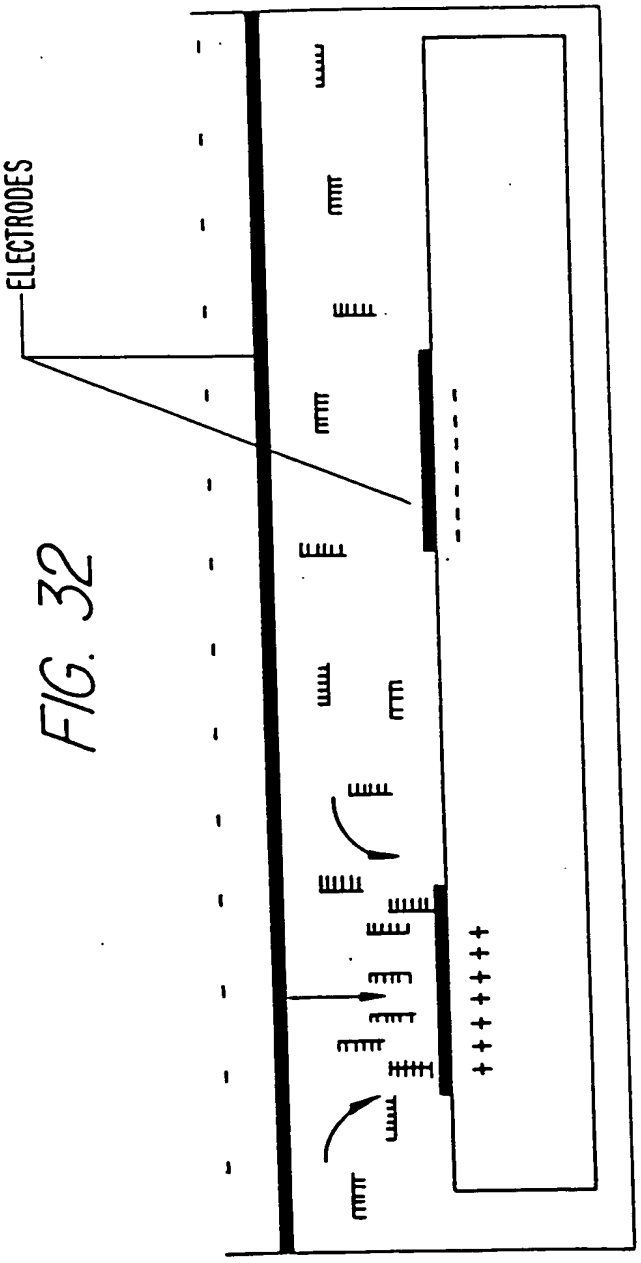


FIG. 32

FIG. 33

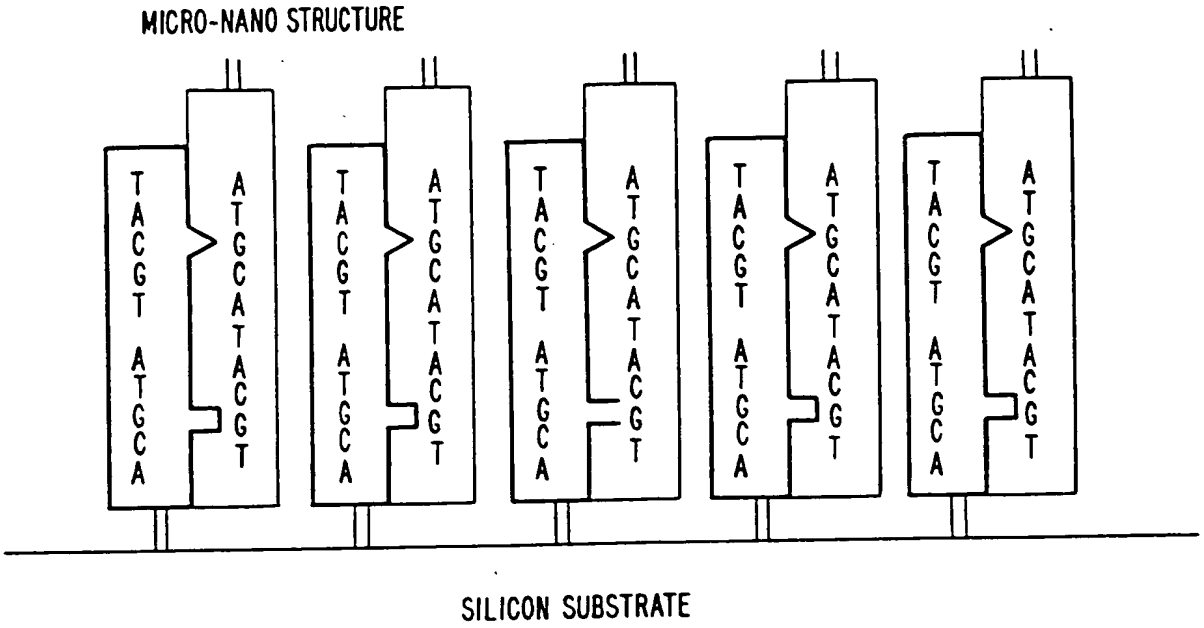

MICRO-NANO STRUCTURE
TACGT ATGCA
ATGCATACGT
SILICON SUBSTRATE

FIG. 34

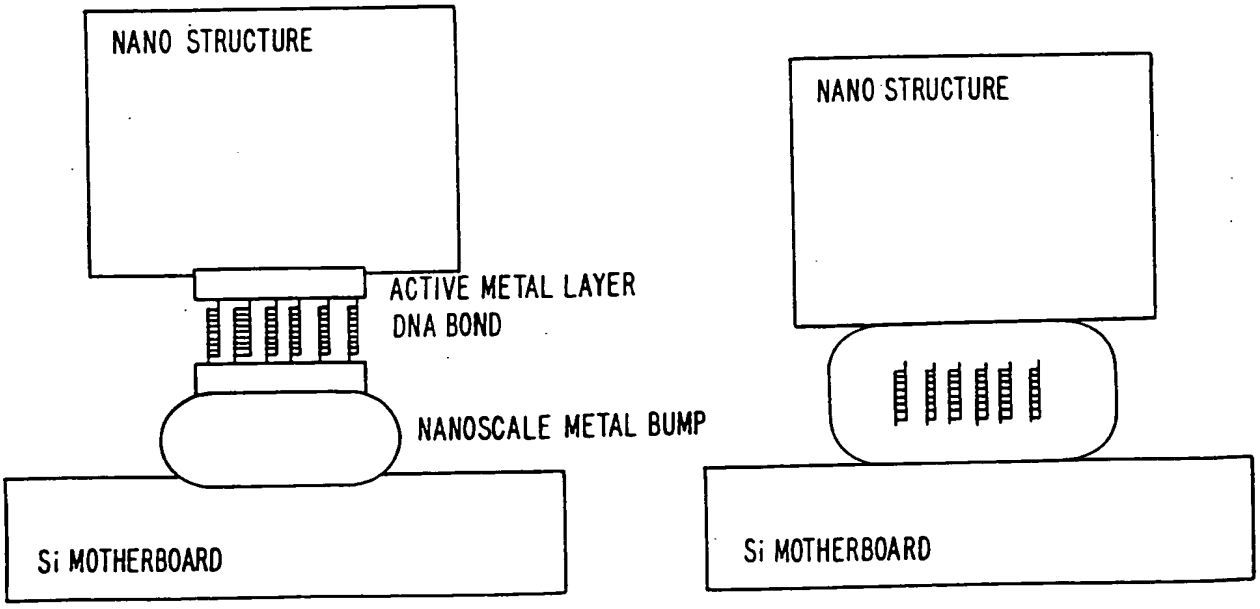
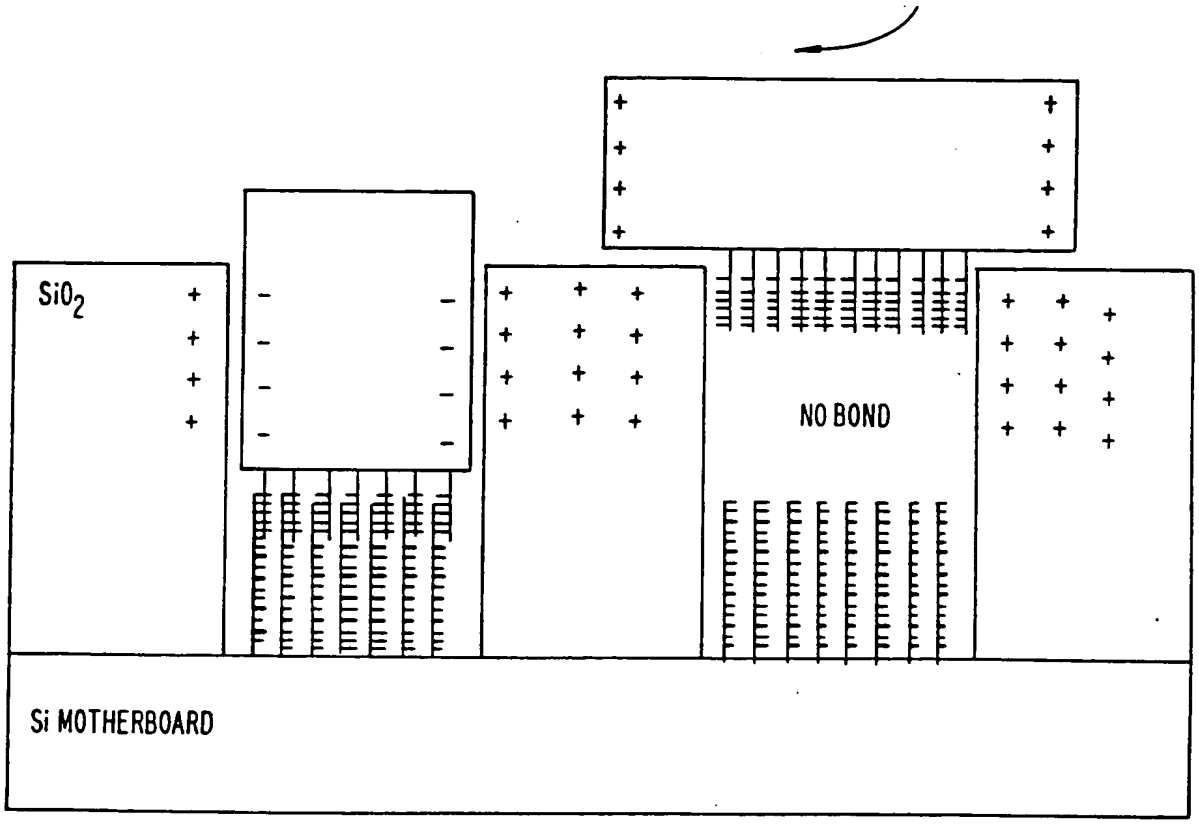
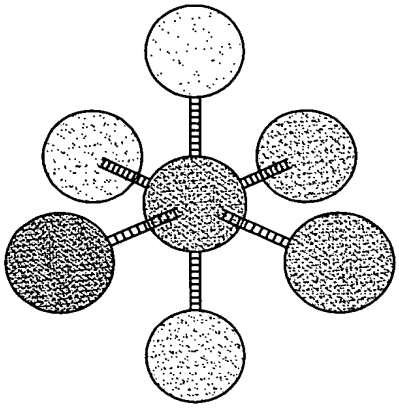
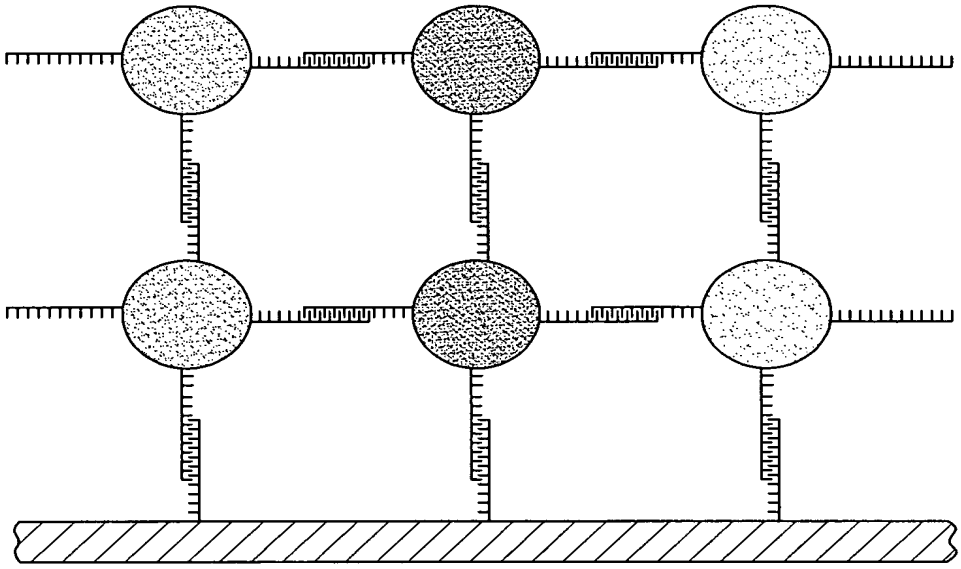

NANO STRUCTURE
ACTIVE METAL LAYER
DNA BOND
NANOSCALE METAL BUMP
Si MOTHERBOARD
NANO STRUCTURE
Si MOTHERBOARD

FIG. 35





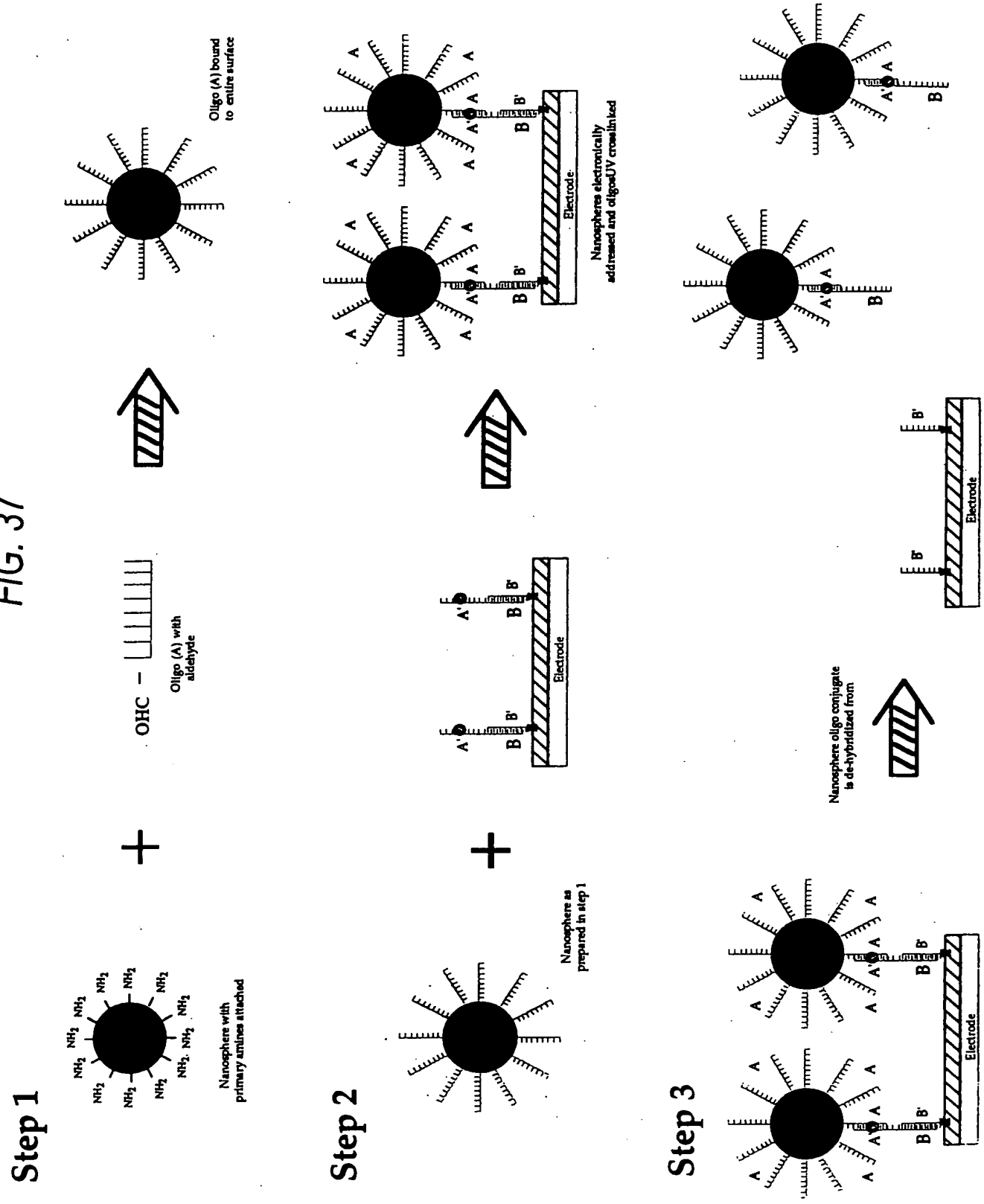
NANOSPHERES ARRANGED IN OCTAHEDRON
USING 3D DNA NANOCONSTRUCTION TECHNIQUES



NANOSPHERES ARRANGED INTO LATTICE STRUCTURE AND BOUND TO SURFACE TO CREATE A 3D DEVICE

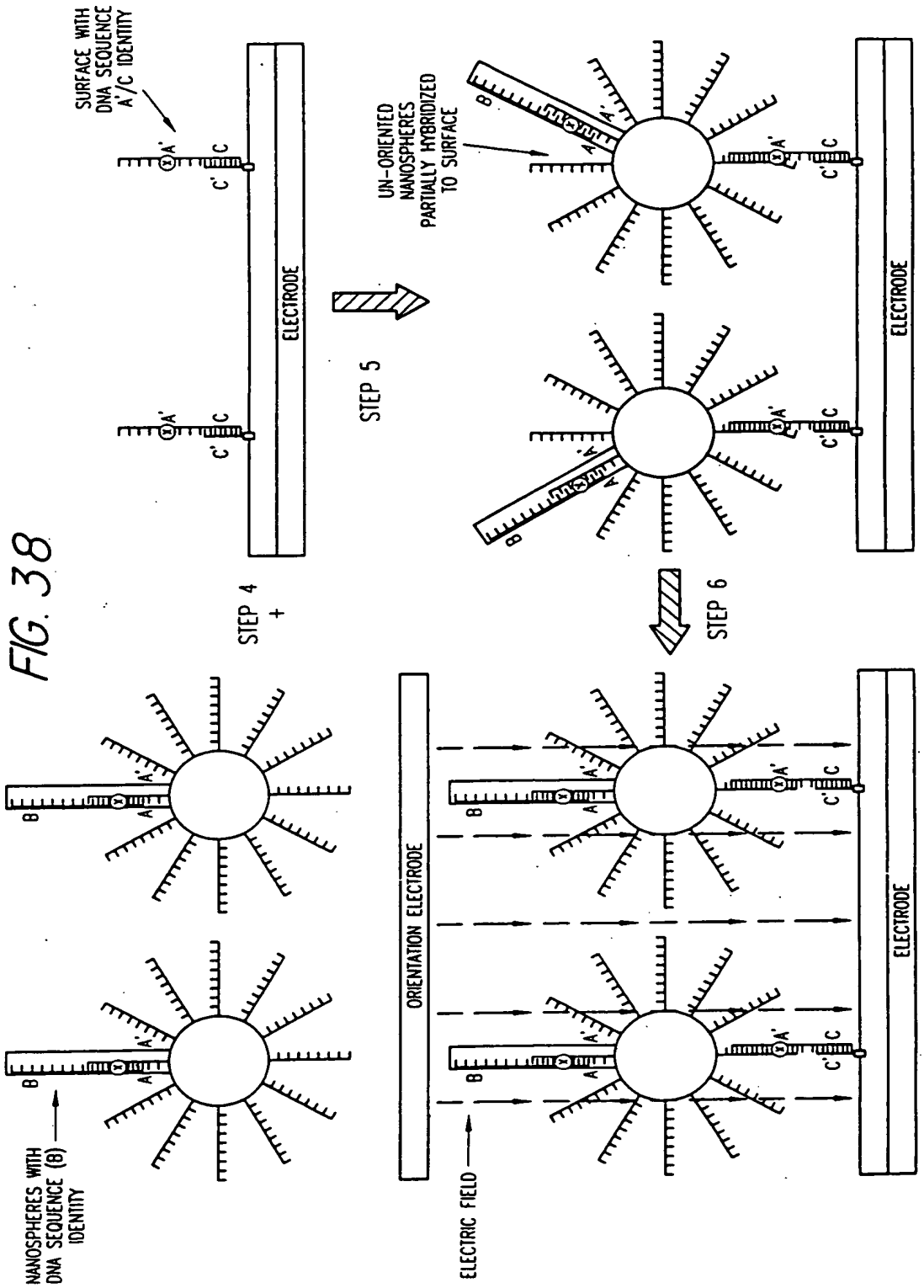
FIG. 36

FIG. 37


Step 1
Step 2
Step 3
Nanosphere with primary amines attached
OHC –
Oligo (A) with aldehyde
Oligo (A) bound to entire surface
Nanosphere as prepared in step 1
Electrode
Nanospheres electronically addressed and oligoUV crosslinked
Nanosphere oligo conjugate is de-hybridized from

Inventors: Edman et al.
Express Mail No. EV337191173US
Title: SYSTEMS AND DEVICES FOR PHOTOELECTROPHORETIC TRANSPORT AND HYBRIDIZATION OF OLIGONUCLEOTIDES

FIG. 38



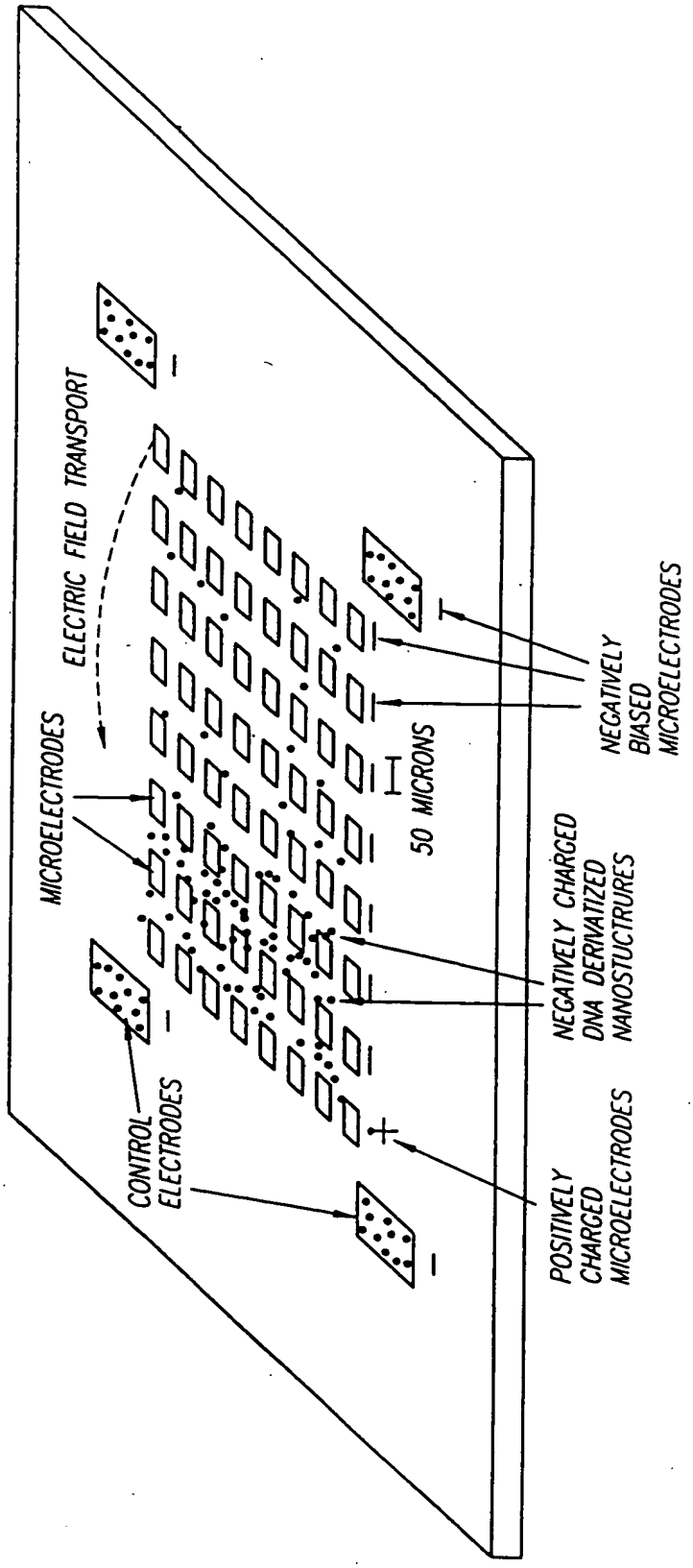

ELECTRIC FIELD TRANSPORT
MICROELECTRODES
50 MICRONS
NEGATIVELY BIASED MICROELECTRODES
NEGATIVELY CHARGED DNA DERIVATIZED NANOSTUCTRURES
CONTROL ELECTRODES
POSITIVELY CHARGED MICROELECTRODES

FIG. 39

NEGATIVELY CHARGED TYPE 1 NANOSTRUCTURES
MOVE TOWARD POSITIVELY BIASED MICROLOCATION

TYPE 1 NANOSTRUCTURES

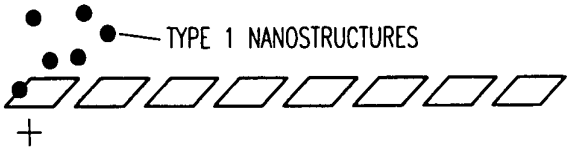


FIG. 40A

TYPE 1 NANOSTRUCTURES ACCUMULATE
ON THE POSITVELY BIASED MICRLOCATION

FIG. 40B

NEGATIVELY CHARGED TYPE 2 NANOSTRUCTURES ARE
INTRODUCED OVER THE ARRAY AND ACCUMULATE
ON THE POSITIVELY BIASED MICROLOCATIONS

TYPE 2 NANOSTRUCTURES

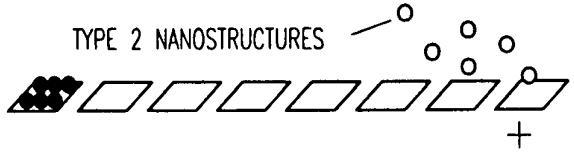


FIG. 40C

BOTH TYPE 1 AND TYPE 2 NANOSTRUCTURES. ARE NOW
CLUSTERED ONTO THEIR RESPECTIVE MICROLOCATIONS

FIG. 40D

ELECTRONICALLY ASSISTED SELF-ASSEMBLY BEGINS WHEN
MICROLOCATION #1 IS BIASED NEGATIVE AND A CENTER
MICROLOCATION IS BIASED POSITIVE CAUSING THE NEGATIVELY
CHARGED TYPE 1 NANOSTRUCTURES TO MOVE TO CENTER LOCATION

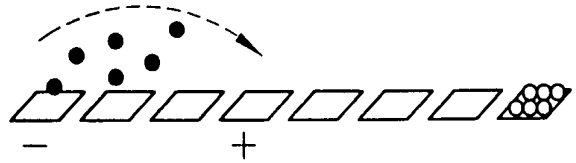


FIG. 40E

TYPE 1 NANOSTRUCTURES ACCUMULATE AND
HYBRIDIZE TO THE SPECIFIC MICROLOCATION

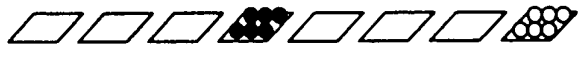


FIG. 40F

TYPE 2 NANOSTRUCTURES ARE MOVED TO CENTER
LOCATION BY BIASING MICROLOCATION #8
NEGATIVE AND CENTER LOCATION POSITIVE

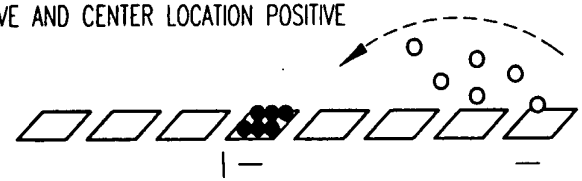
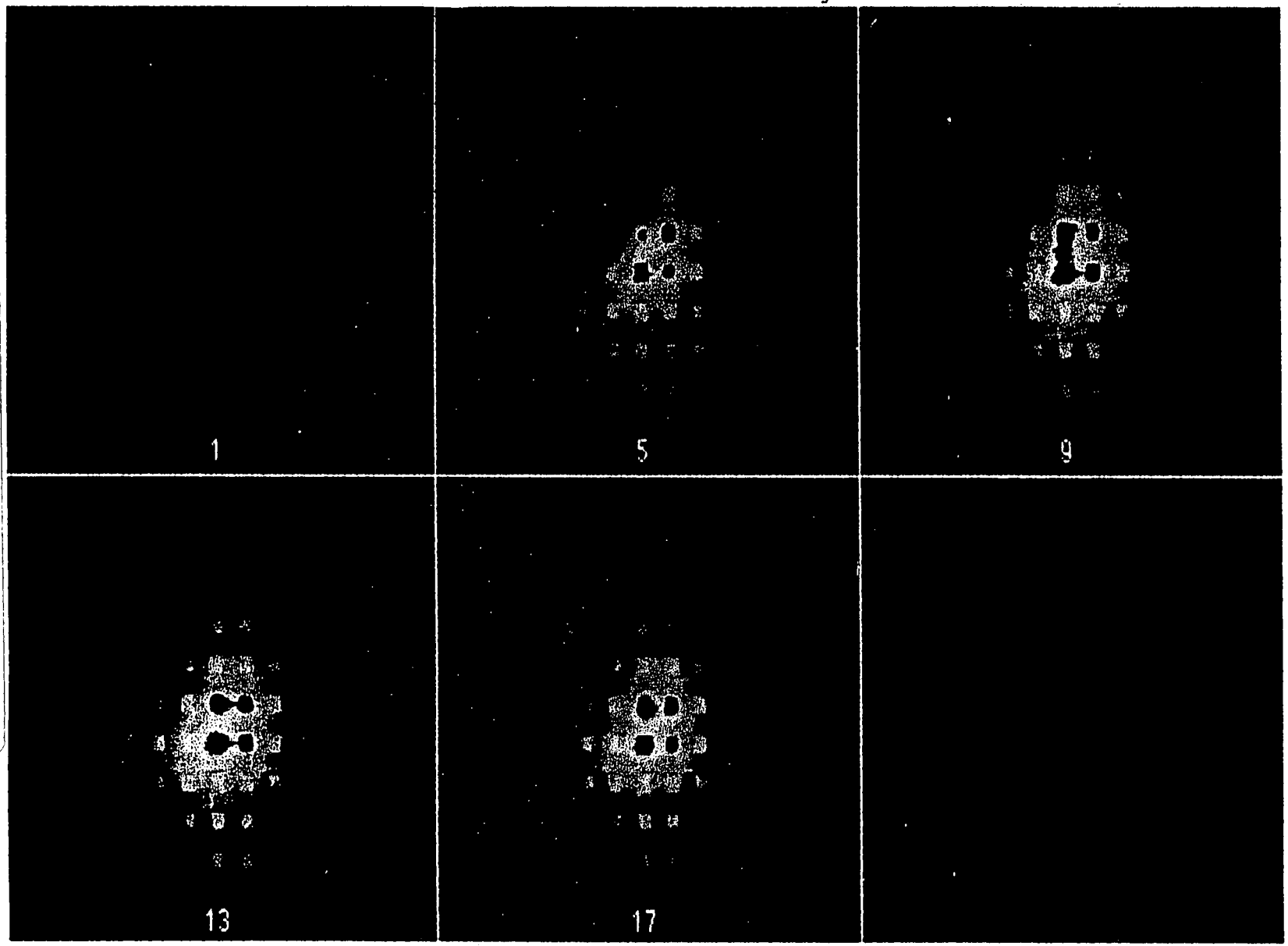


FIG. 40G

TYPE 2 NANOSTRUCTURES CONTAINING COMPLEMENTARY
DNA SEQUENCE HYBRIDIZE TO TYPE 1 NANOSTRUCTURES

FIG. 40H

Fig. 41. Transport and concentration of negatively charged fluorescent nanospheres onto selected microlocations of a microelectronic array device.



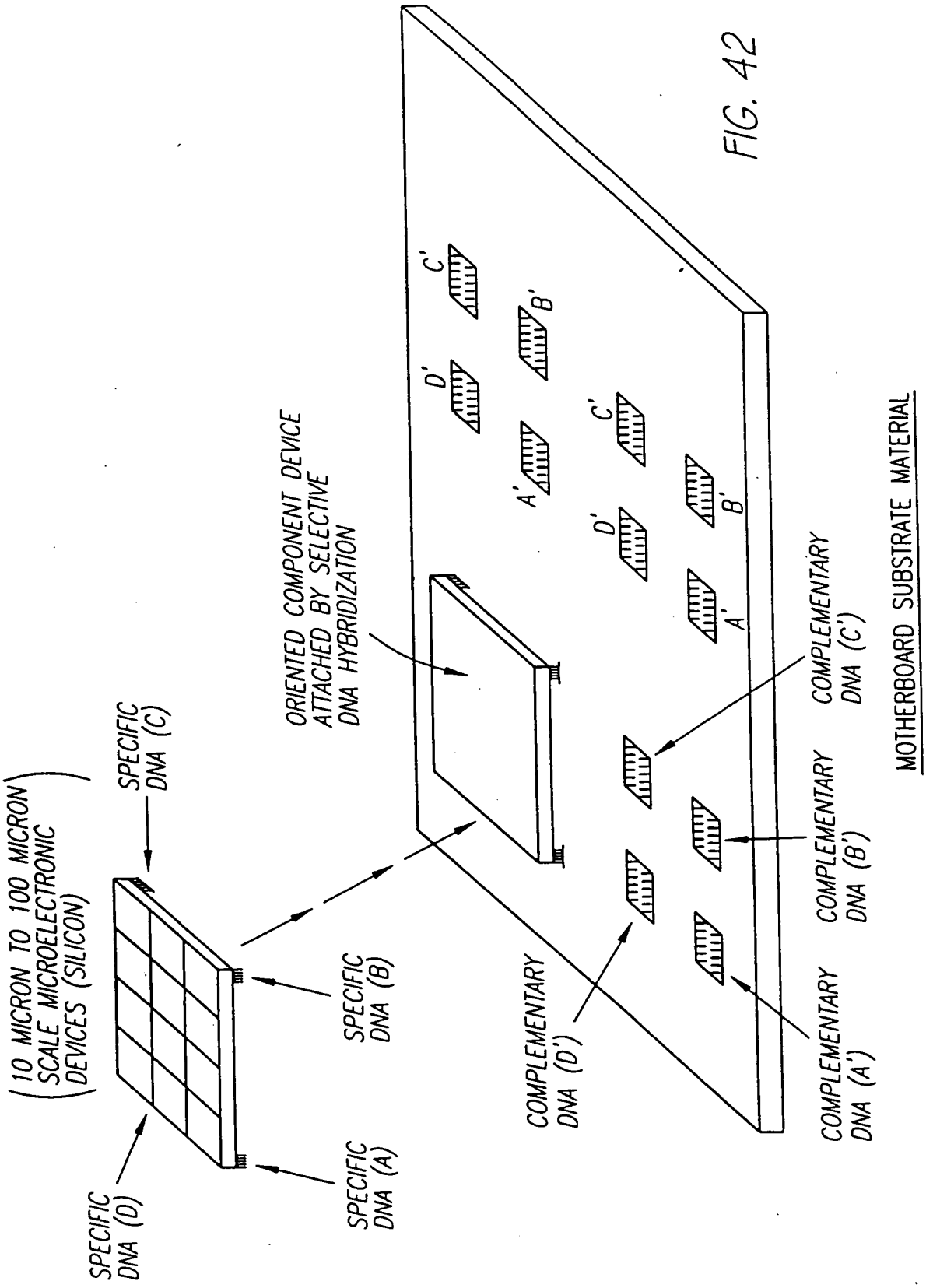

(10 MICRON TO 100 MICRON SCALE MICROELECTRONIC DEVICES (SILICON)
SPECIFIC DNA (C)
SPECIFIC DNA (B)
SPECIFIC DNA (D)
SPECIFIC DNA (A)
ORIENTED COMPONENT DEVICE ATTACHED BY SELECTIVE DNA HYBRIDIZATION
COMPLEMENTARY DNA (D')
COMPLEMENTARY DNA (B')
COMPLEMENTARY DNA (C')
COMPLEMENTARY DNA (A')
MOTHERBOARD SUBSTRATE MATERIAL

FIG. 42

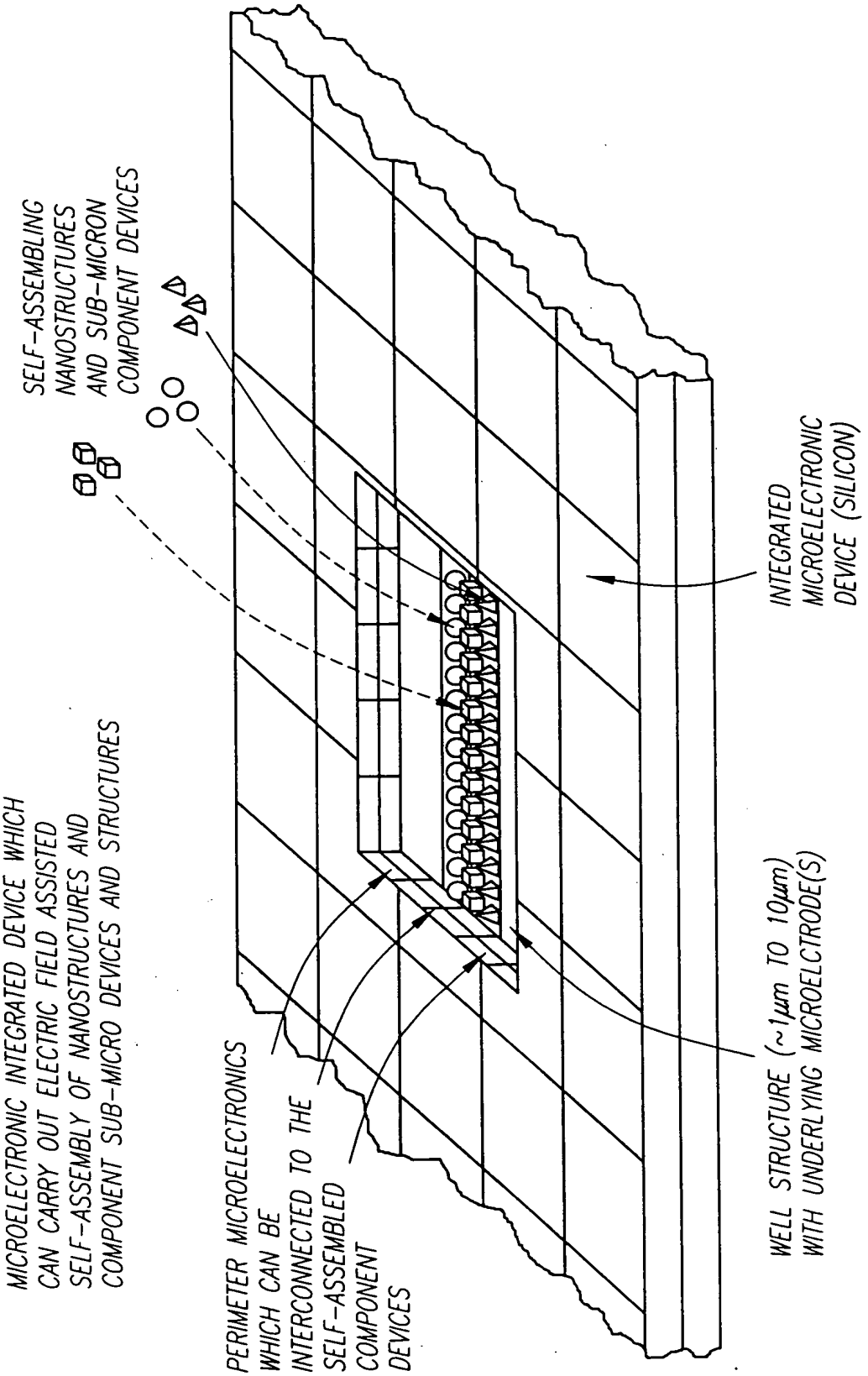

MICROELECTRONIC INTEGRATED DEVICE WHICH CAN CARRY OUT ELECTRIC FIELD ASSISTED SELF-ASSEMBLY OF NANOSTRUCTURES AND COMPONENT SUB-MICRO DEVICES AND STRUCTURES
SELF-ASSEMBLING NANOSTRUCTURES AND SUB-MICRON COMPONENT DEVICES
PERIMETER MICROELECTRONICS WHICH CAN BE INTERCONNECTED TO THE SELF-ASSEMBLED COMPONENT DEVICES
WELL STRUCTURE (~1μm TO 10μm) WITH UNDERLYING MICROELCTRODE(S)
INTEGRATED MICROELECTRONIC DEVICE (SILICON)

FIG. 43

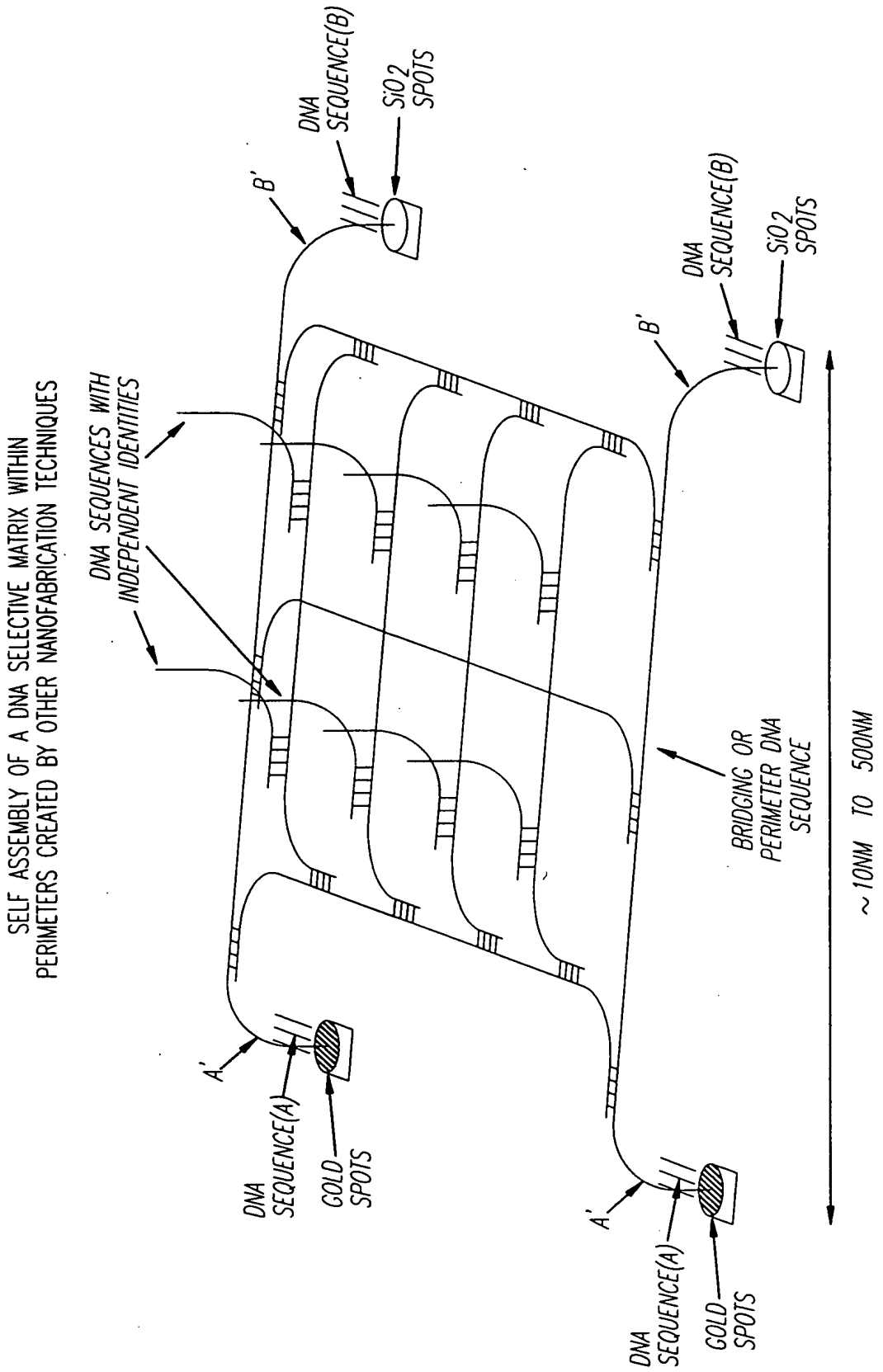

SELF ASSEMBLY OF A DNA SELECTIVE MATRIX WITHIN PERIMETERS CREATED BY OTHER NANOFABRICATION TECHNIQUES
DNA SEQUENCES WITH INDEPENDENT IDENTITIES
B'
DNA SEQUENCE(B)
SiO2 SPOTS
B'
DNA SEQUENCE(B)
SiO2 SPOTS
BRIDGING OR PERIMETER DNA SEQUENCE
~10NM TO 500NM
A'
DNA SEQUENCE(A)
GOLD SPOTS
A'
DNA SEQUENCE(A)
GOLD SPOTS

FIG. 44

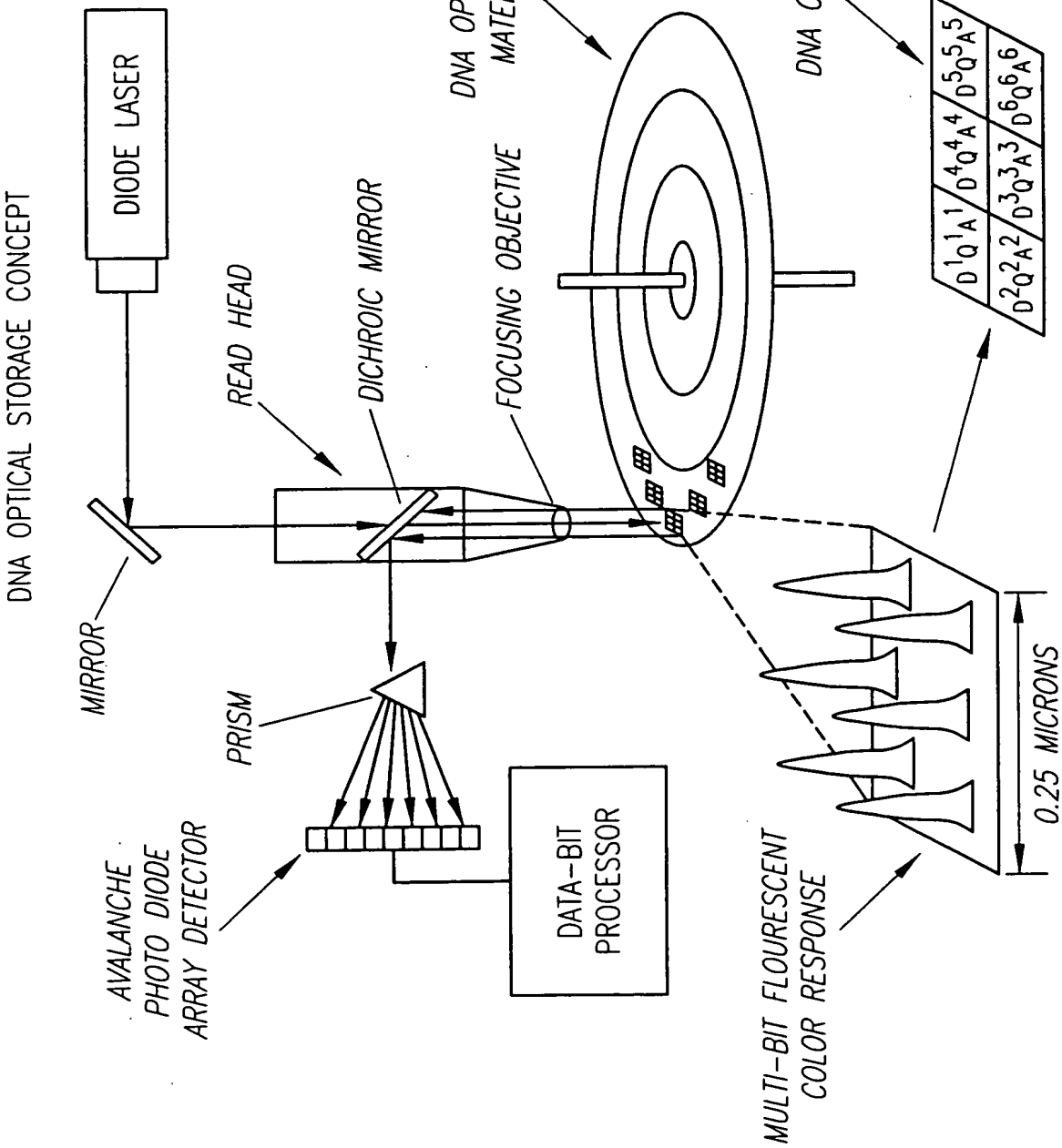

DNA OPTICAL STORAGE CONCEPT
DIODE LASER
READ HEAD
DICHROIC MIRROR
FOCUSING OBJECTIVE
DNA OPTICAL STORAGE MATERIAL "DOSM"
DNA CHROMOPHORE UNITS
MIRROR
PRISM
AVALANCHE PHOTO DIODE ARRAY DETECTOR
DATA-BIT PROCESSOR
MULTI-BIT FLOURESCENT COLOR RESPONSE
0.25 MICRONS

FIG. 45

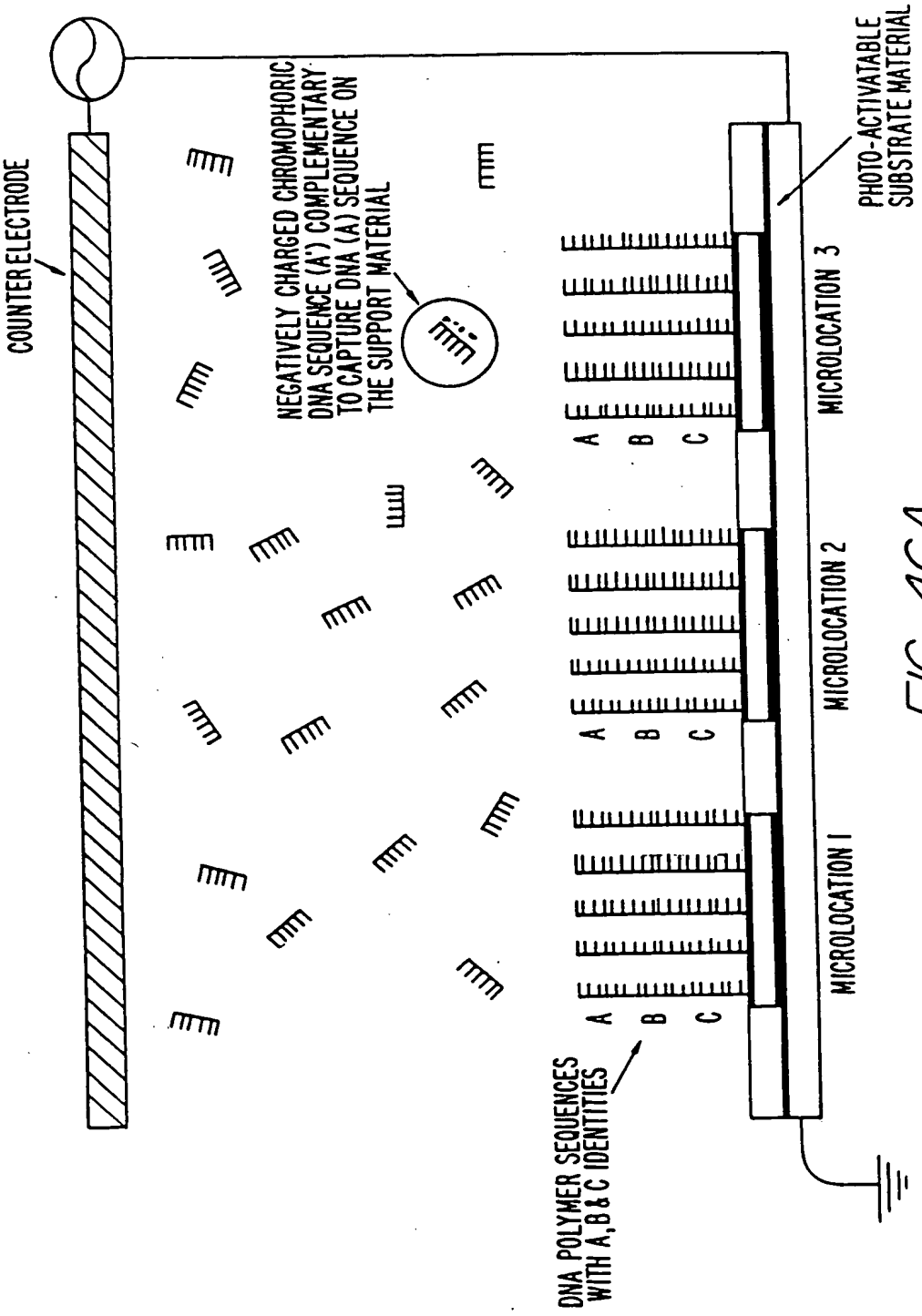

COUNTER ELECTRODE
NEGATIVELY CHARGED CHROMOPHORIC DNA SEQUENCE (A') COMPLEMENTARY TO CAPTURE DNA (A) SEQUENCE ON THE SUPPORT MATERIAL
PHOTO-ACTIVATABLE SUBSTRATE MATERIAL
MICROLOCATION 3
MICROLOCATION 2
MICROLOCATION 1
A
B
C
DNA POLYMER SEQUENCES WITH A, B & C IDENTITIES

FIG. 46A

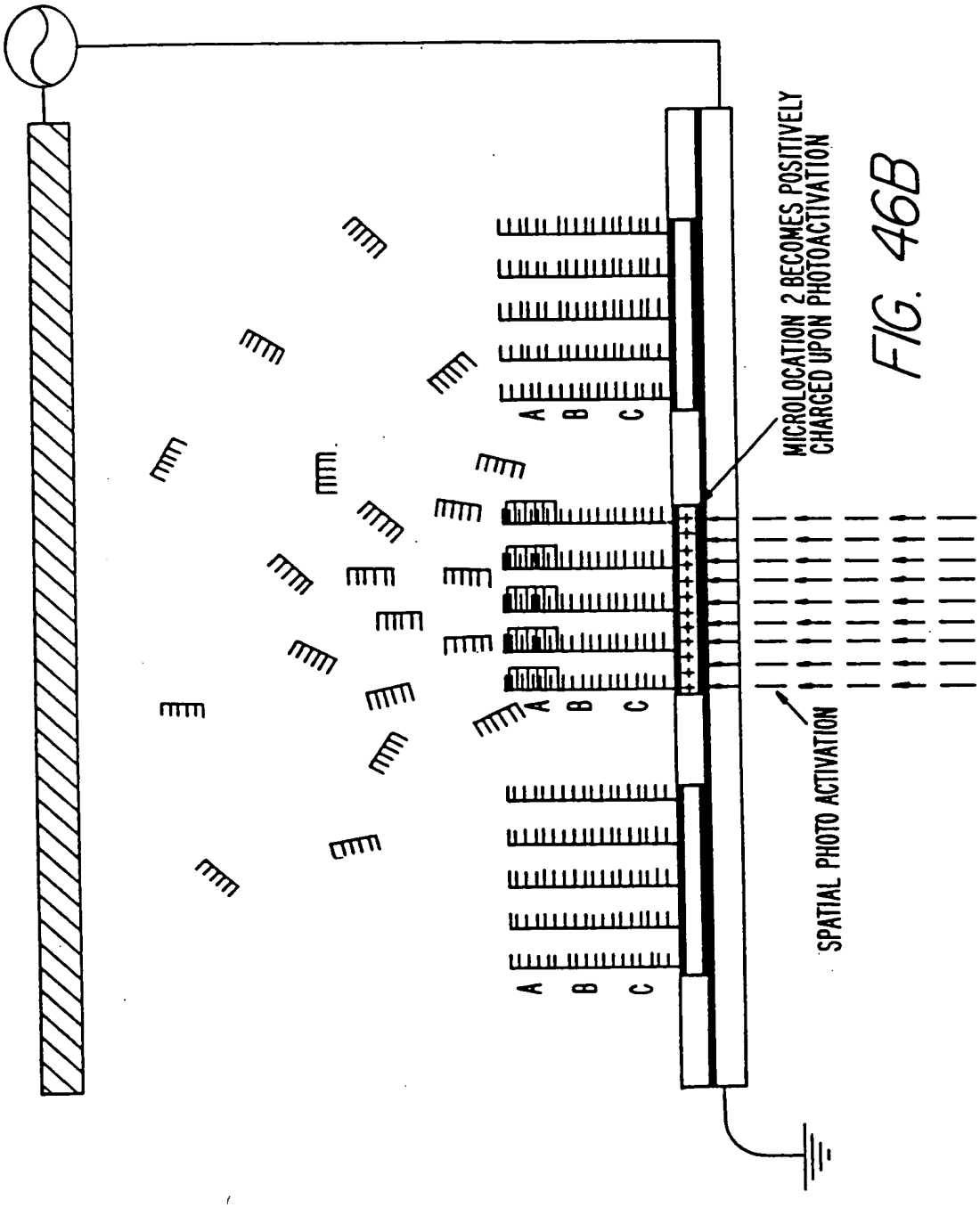

MICROLOCATION 2 BECOMES POSITIVELY CHARGED UPON PHOTOACTIVATION
SPATIAL PHOTO ACTIVATION
A
B
C
A
B
C
A
B
C

FIG. 46B

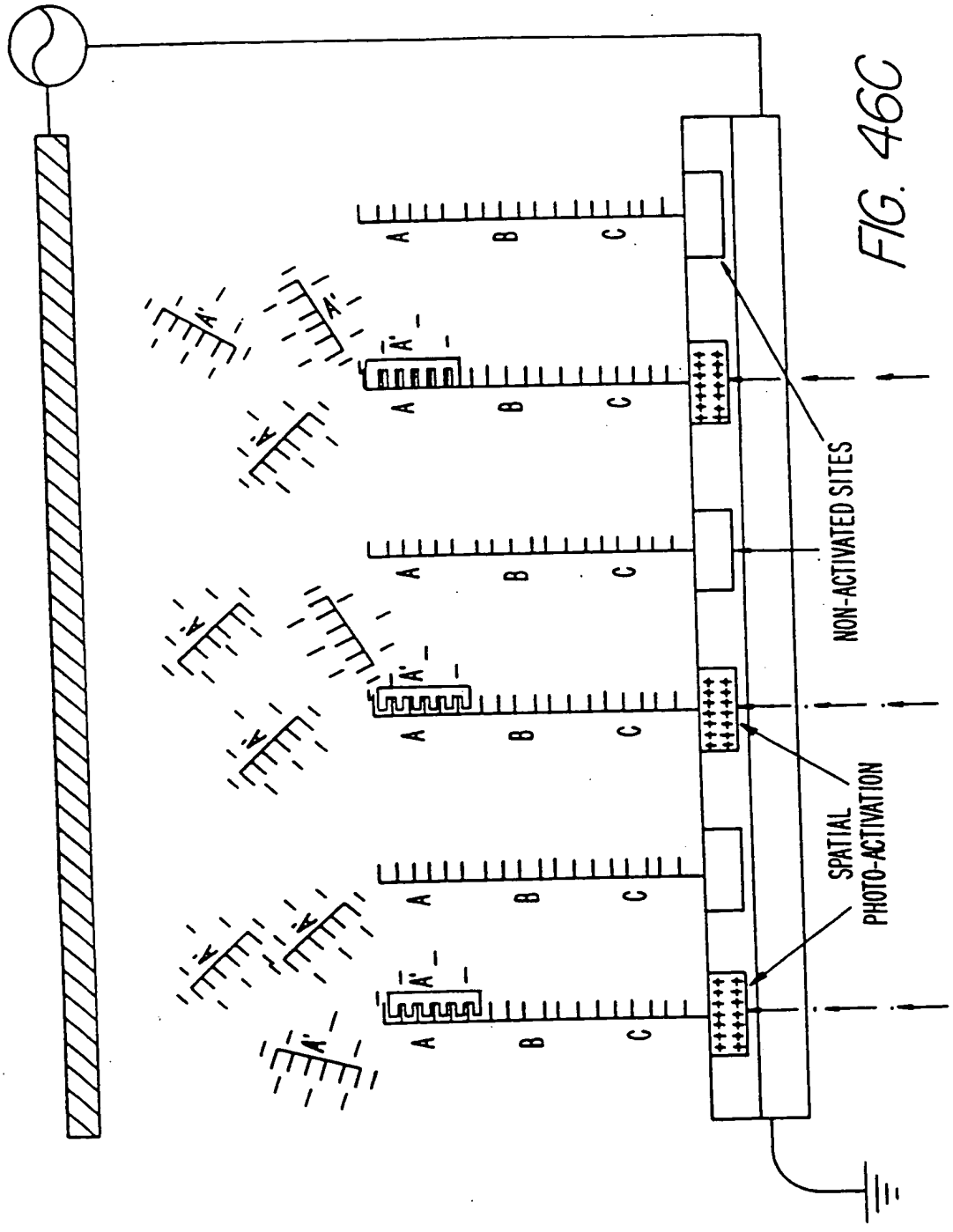


FIG. 46C

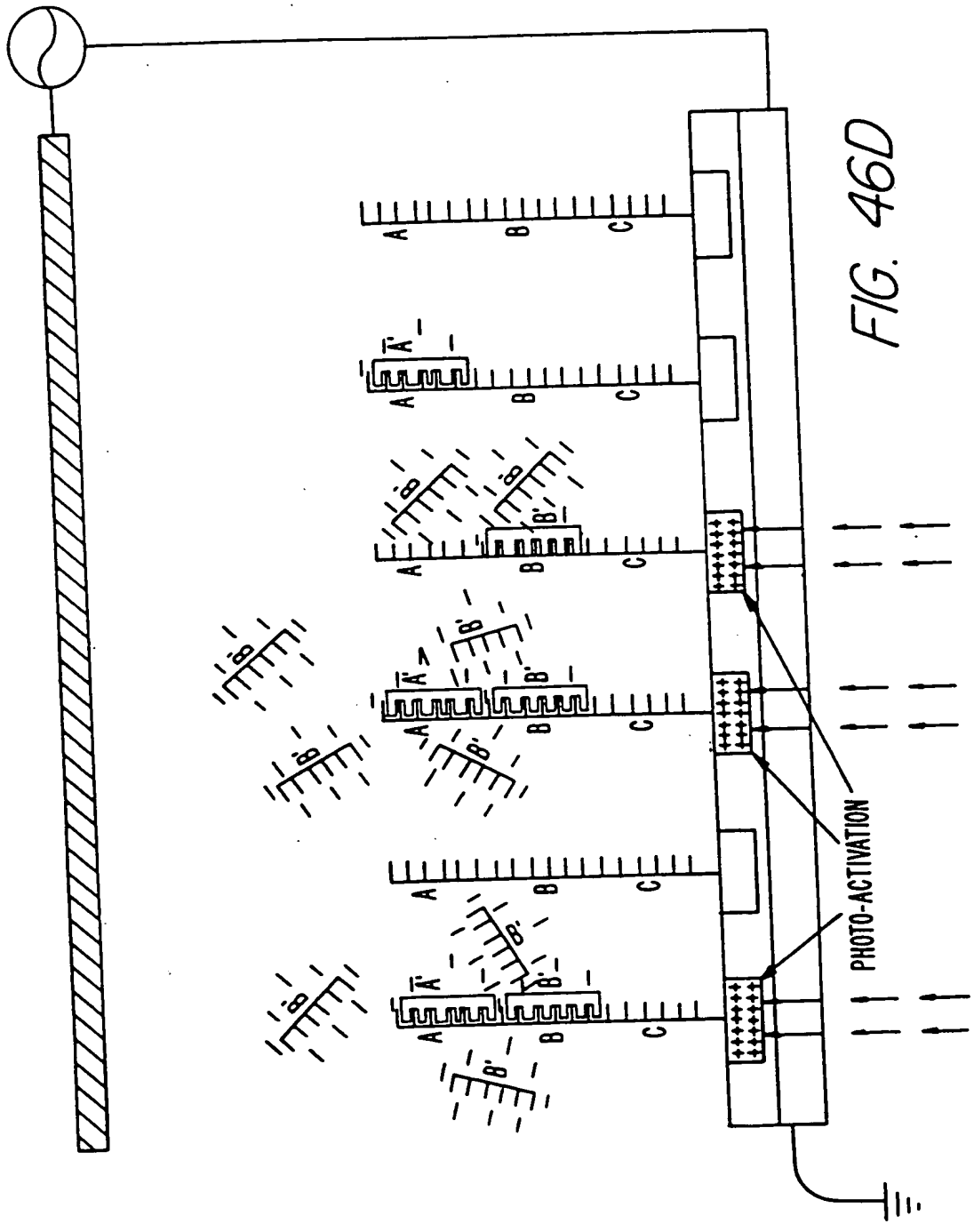


FIG. 46D

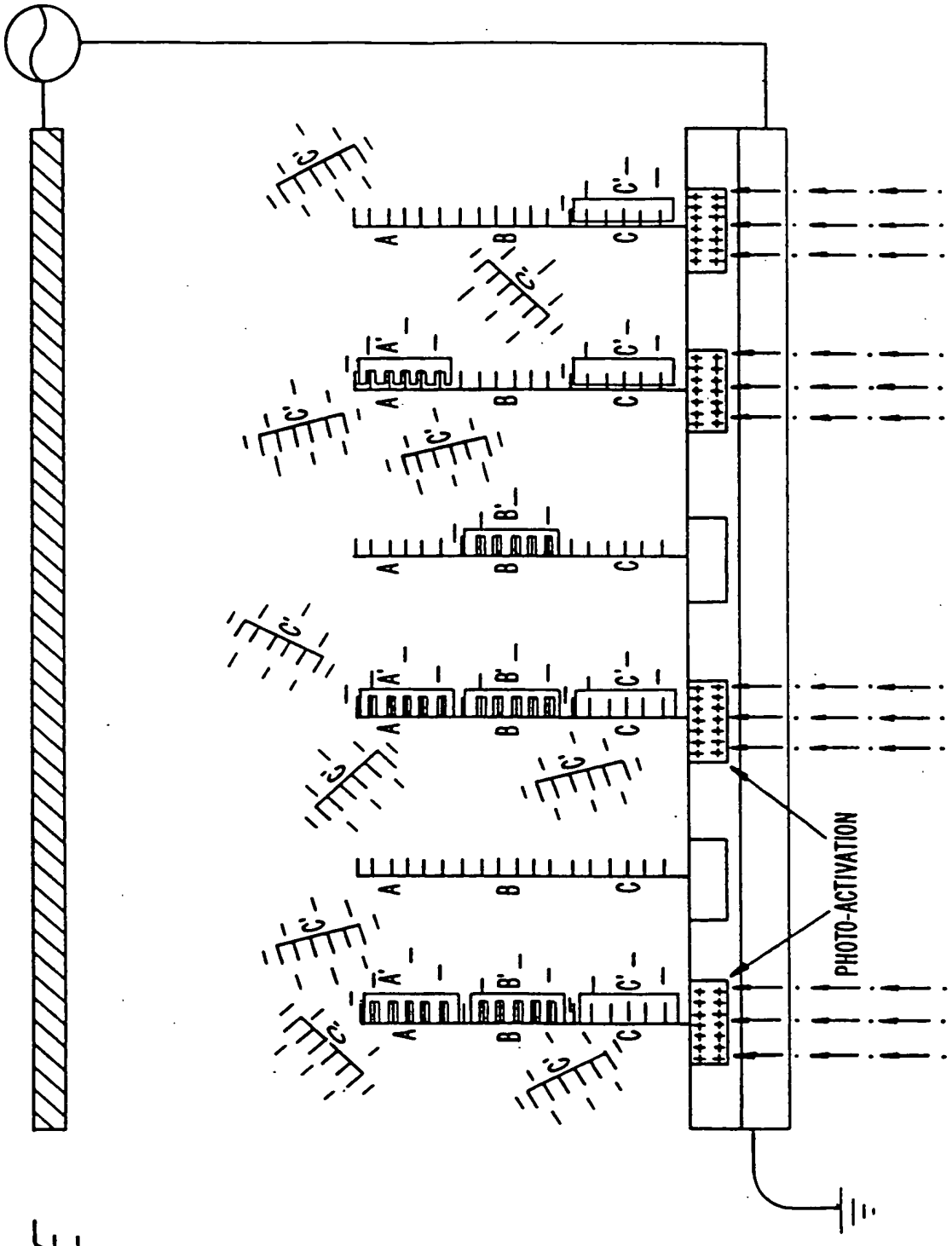
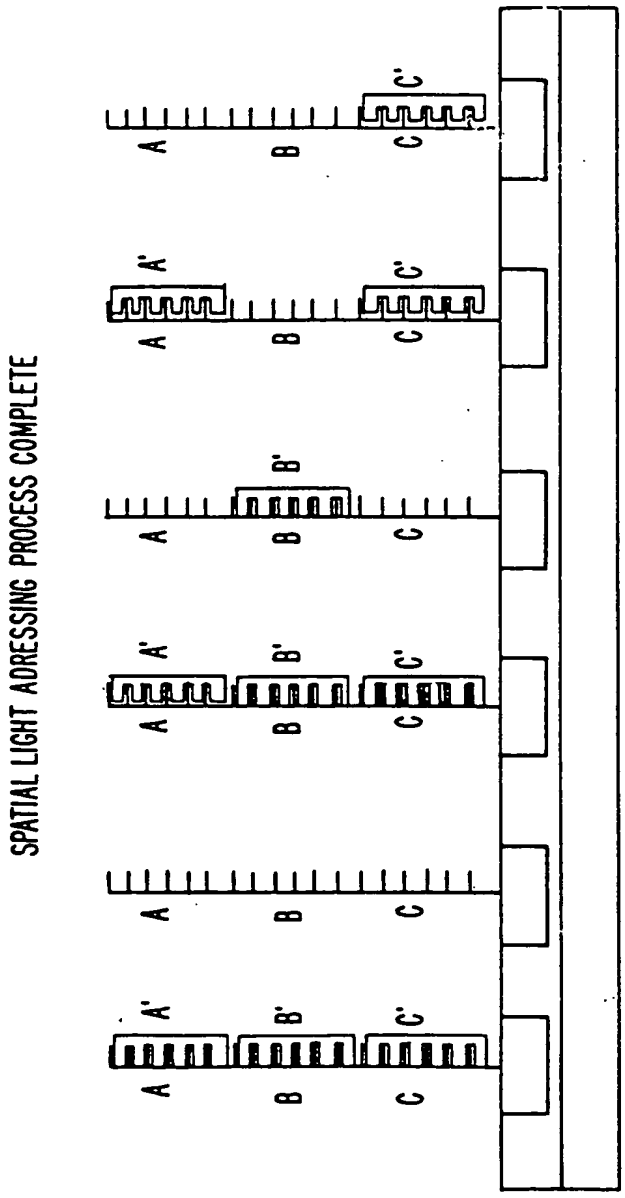


FIG. 46E

FIG. 46F



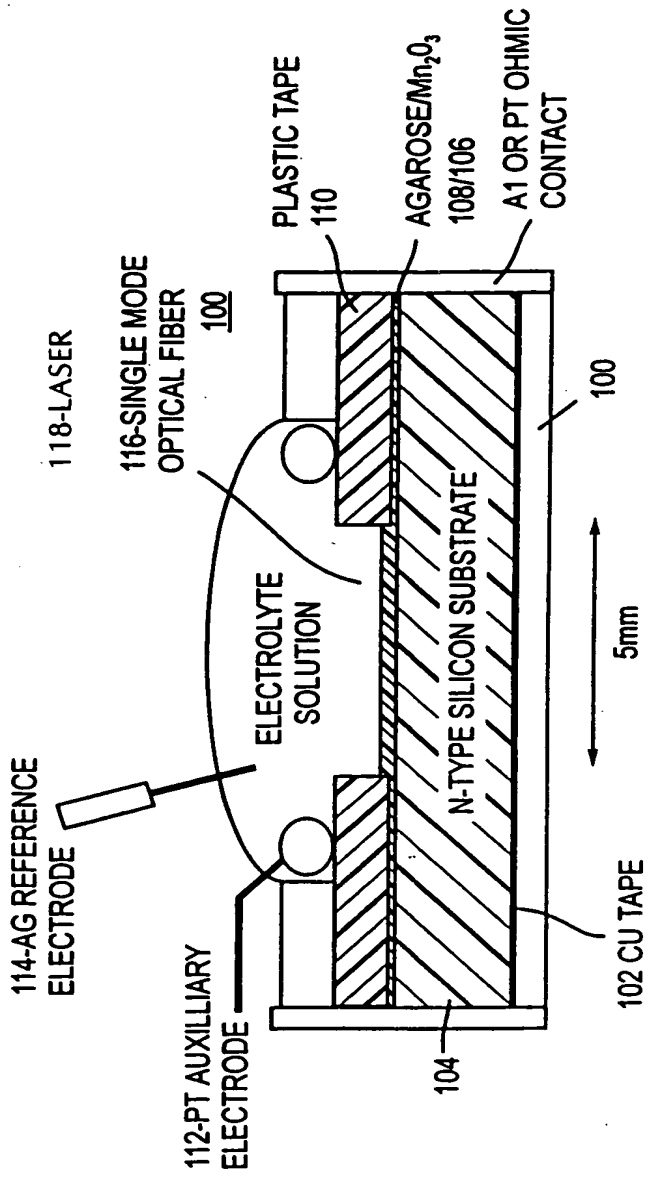

PLASTIC TAPE
110
AGAROSE/Mn_2O_3
108/106
A1 OR PT OHMIC CONTACT
118-LASER
116-SINGLE MODE OPTICAL FIBER
100
100
ELECTROLYTE SOLUTION
N-TYPE SILICON SUBSTRATE
5mm
114-AG REFERENCE ELECTRODE
102 CU TAPE
112-PT AUXILLIARY ELECTRODE
104

FIG. 47

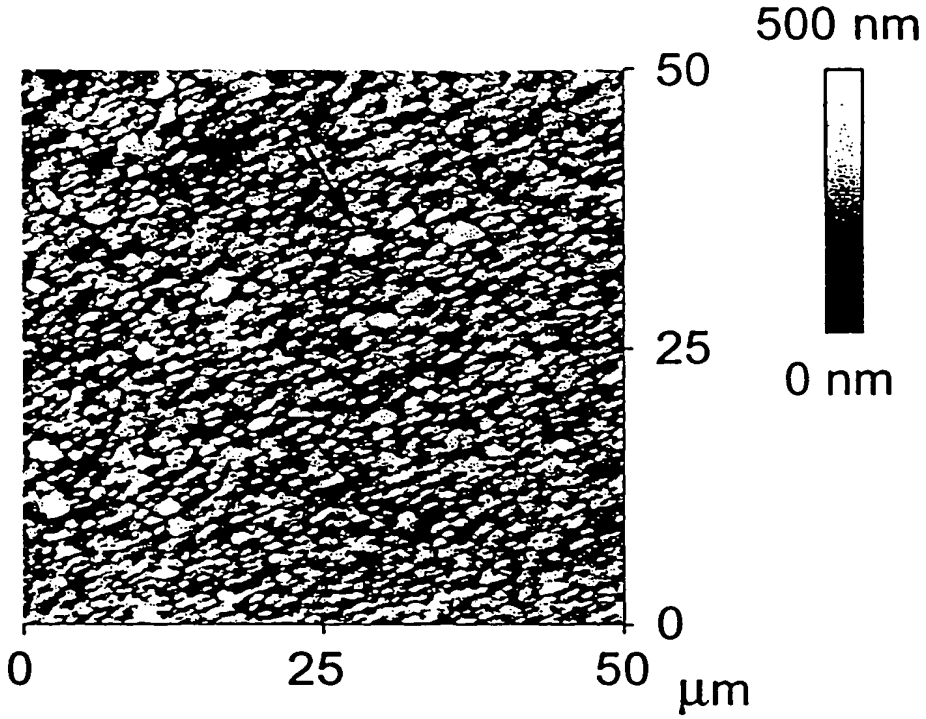


Figure 48 A

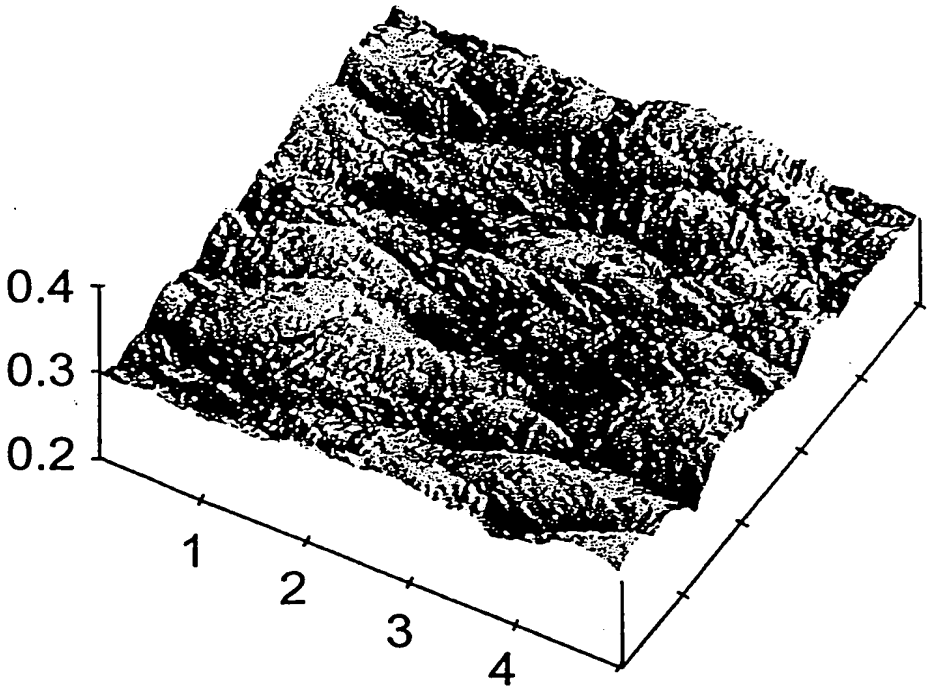


Figure 48 B

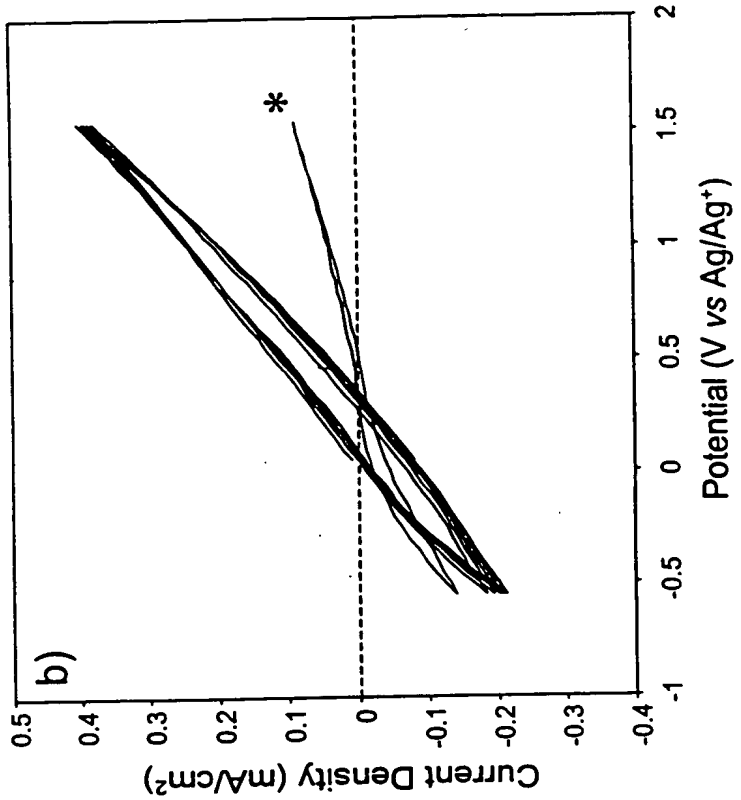


FIG. 49B.

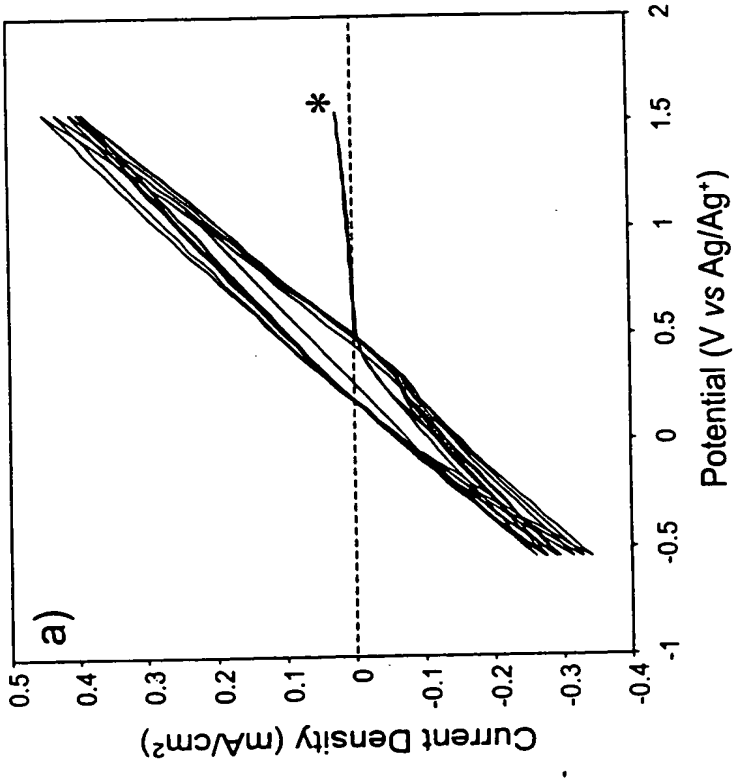


FIG. 49A.

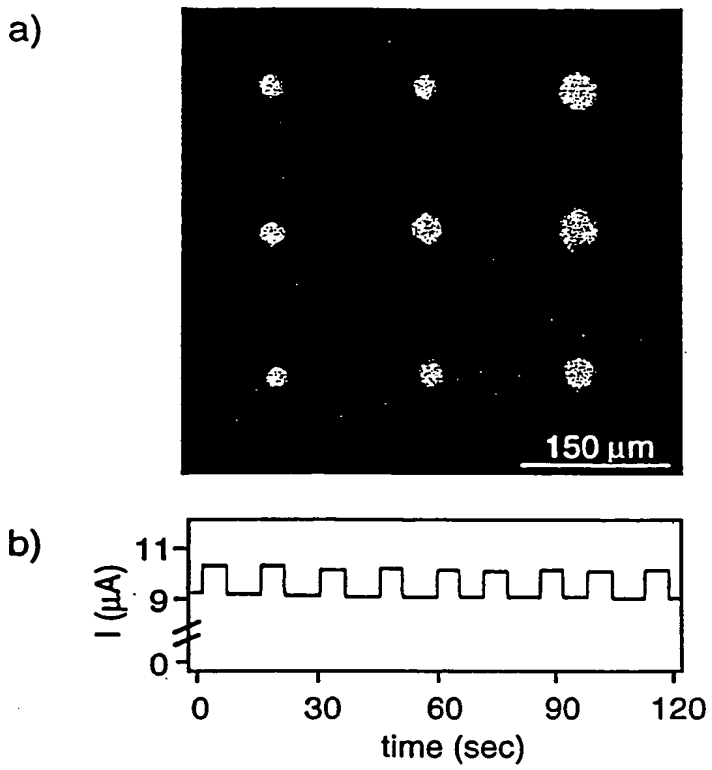


Figure 50

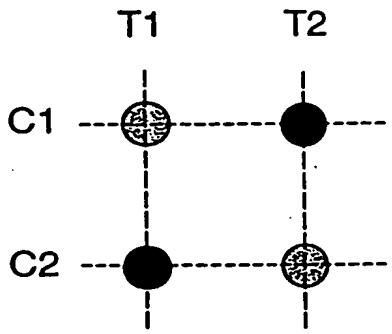


Figure 51 A

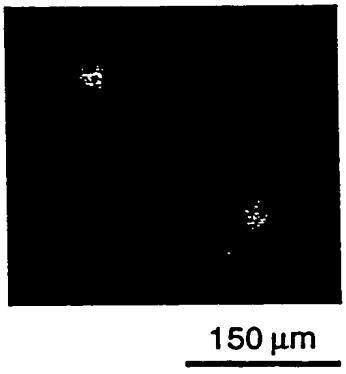


Figure 51 B

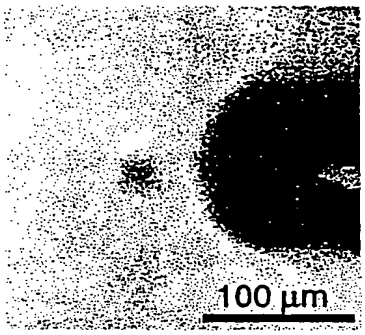


Figure 52